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SCRUFY

energy saving device
..for sustainable shipping

EENMA

presentation: 20 May 2021

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robotics

for sustainable shipping

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agenda

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IMO (MEPC.203(62)) July 2011."Guidance for the development of a ship energy efficiency management plan (SEEMP)" EEDI and SEEMP become mandatory from 01 January 2013.

the pain

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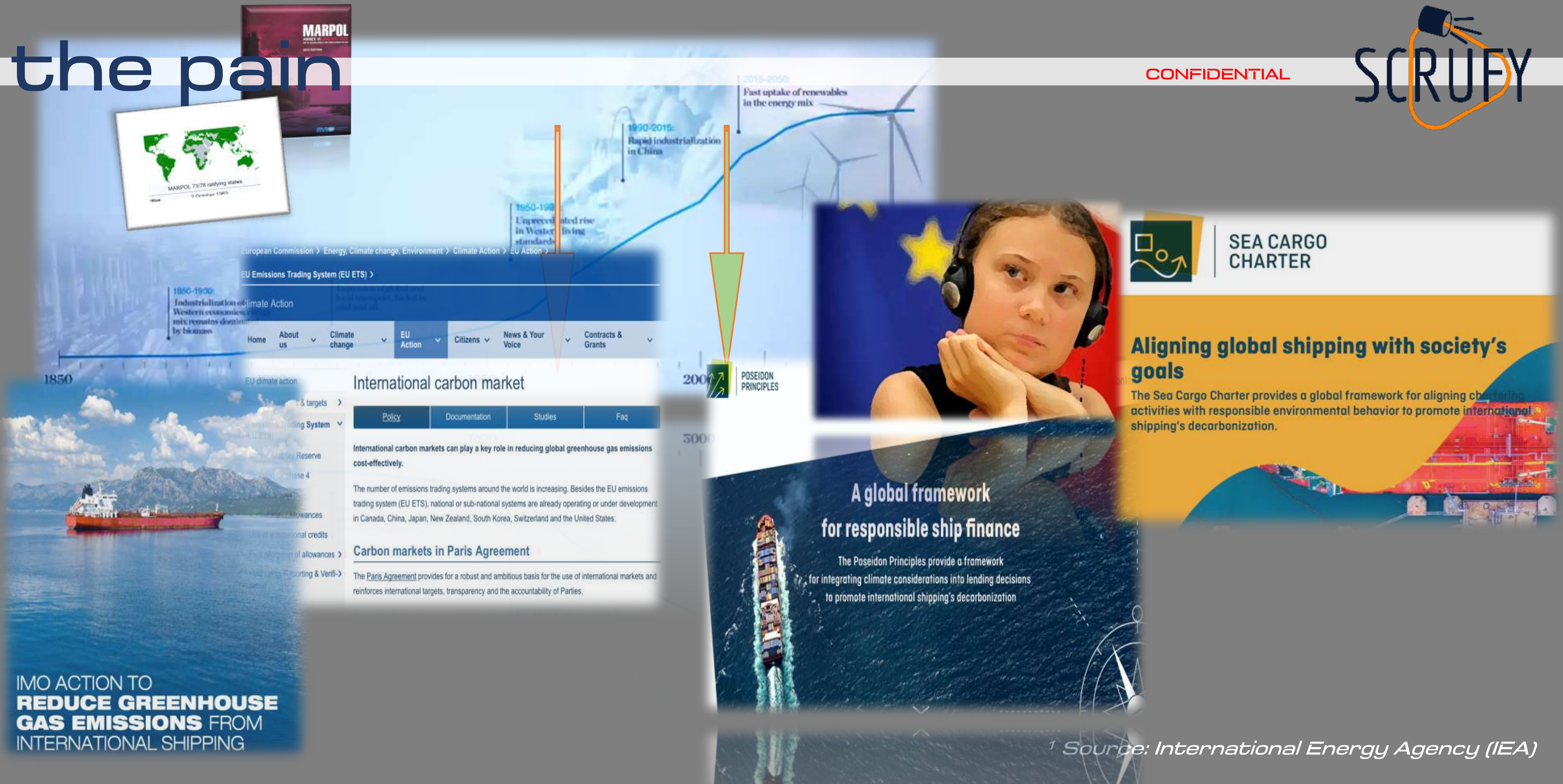

[1] Source: International Energy Agency (IEA)

the pain

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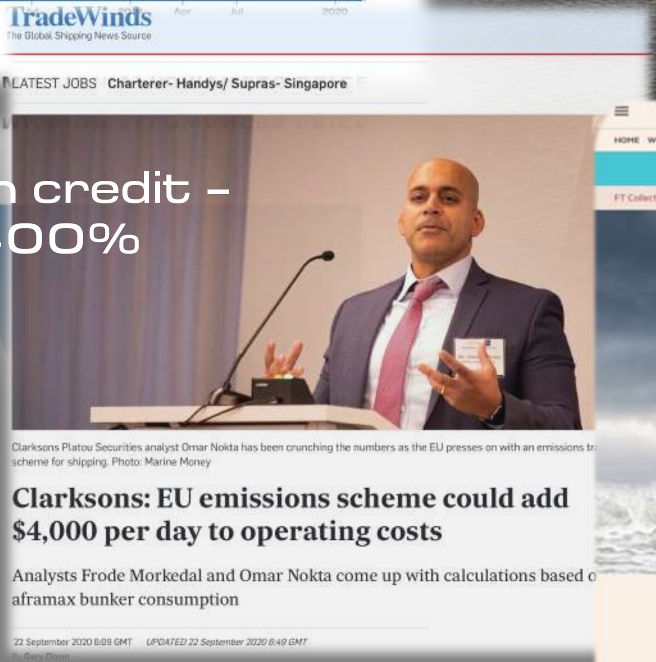
CO_2 emission credit – value risen 400% since 2017

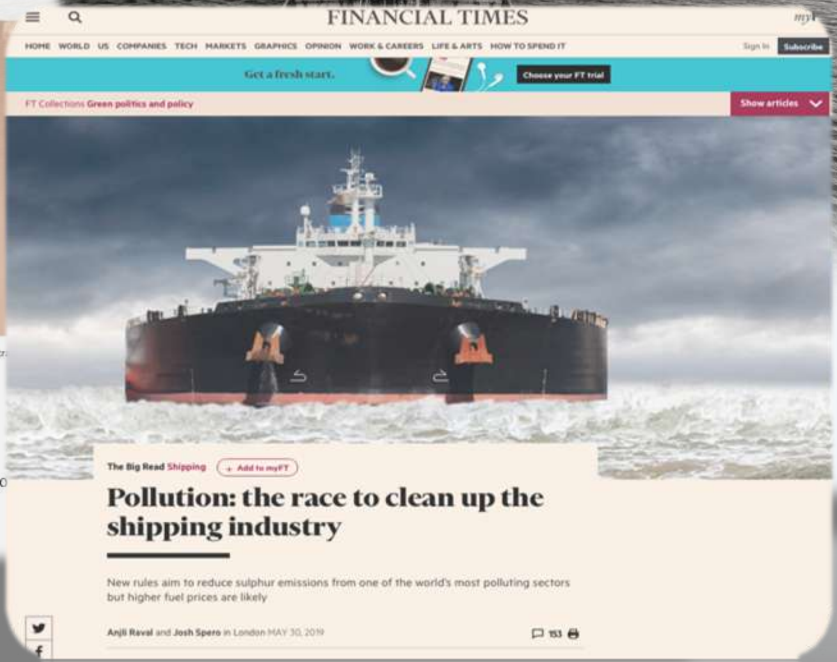

TradeWinds
The Global Shipping News Source
LATEST JOBS Charterer- Handys/ Supras- Singapore

Clarksons Platou Securities analyst Omar Nokta has been crunching the numbers as the EU presses on with an emissions tr scheme for shipping. Photo: Marine Money

Clarksons: EU emissions scheme could add $4,000 per day to operating costs

Analysts Frode Morkedal and Omar Nokta come up with calculations based o aframax bunker consumption

22 September 2020 6:09 GMT UPDATED 22 September 2020 6:49 GMT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Pollution: the race to clean up the shipping industry

New rules aim to reduce sulphur emissions from one of the world's most polluting sectors but higher fuel prices are likely

Anjli Raval and Josh Spero in London MAY 30, 2019


TRANSPORT & ENVIRONMENT

Shipping's impact on air quality

Learn about the health and environmental impacts of poor air quality due to shipping pollution – and what measures can be taken to reduce ship emissions.

the monster

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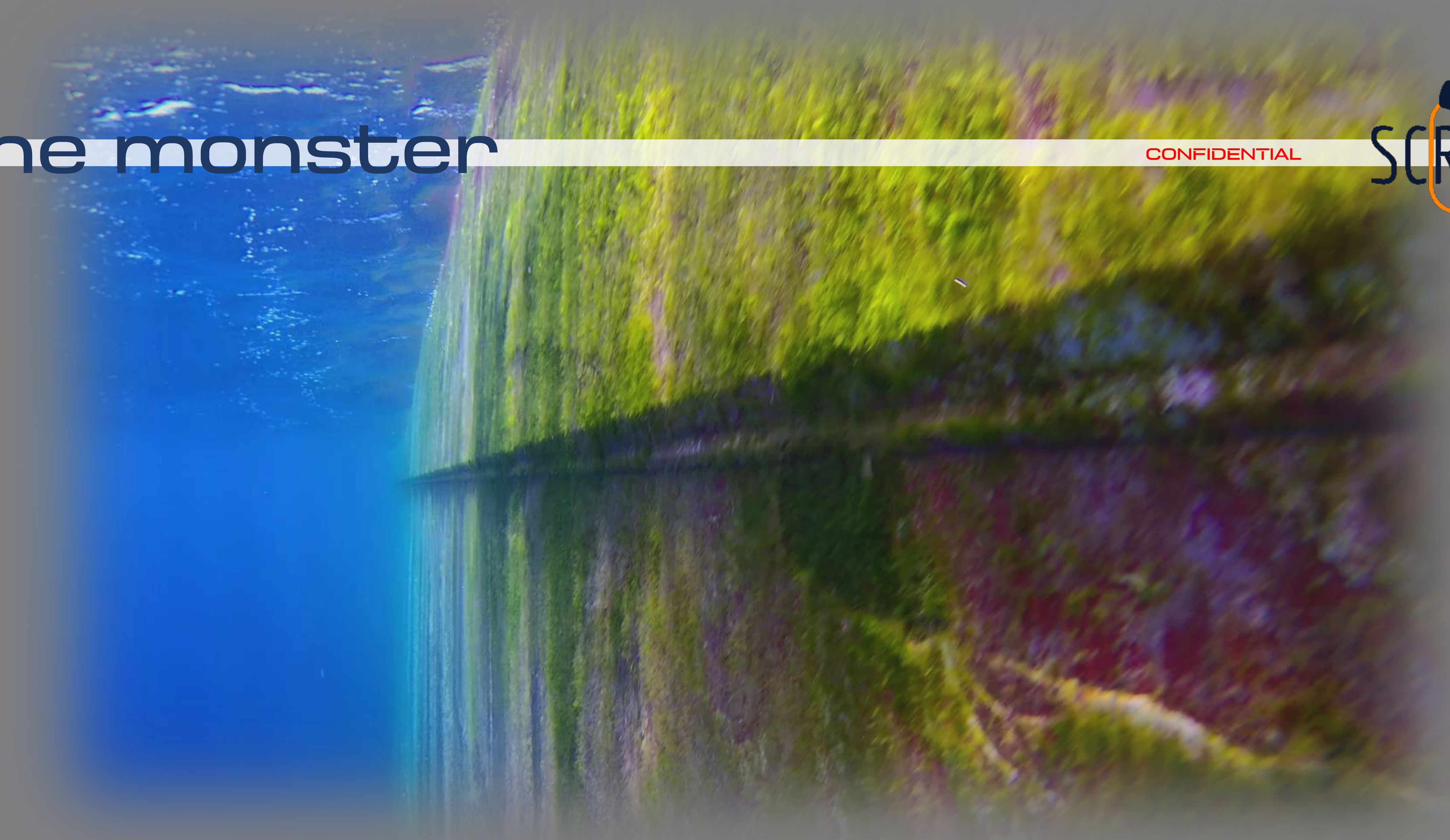

the traditional approach

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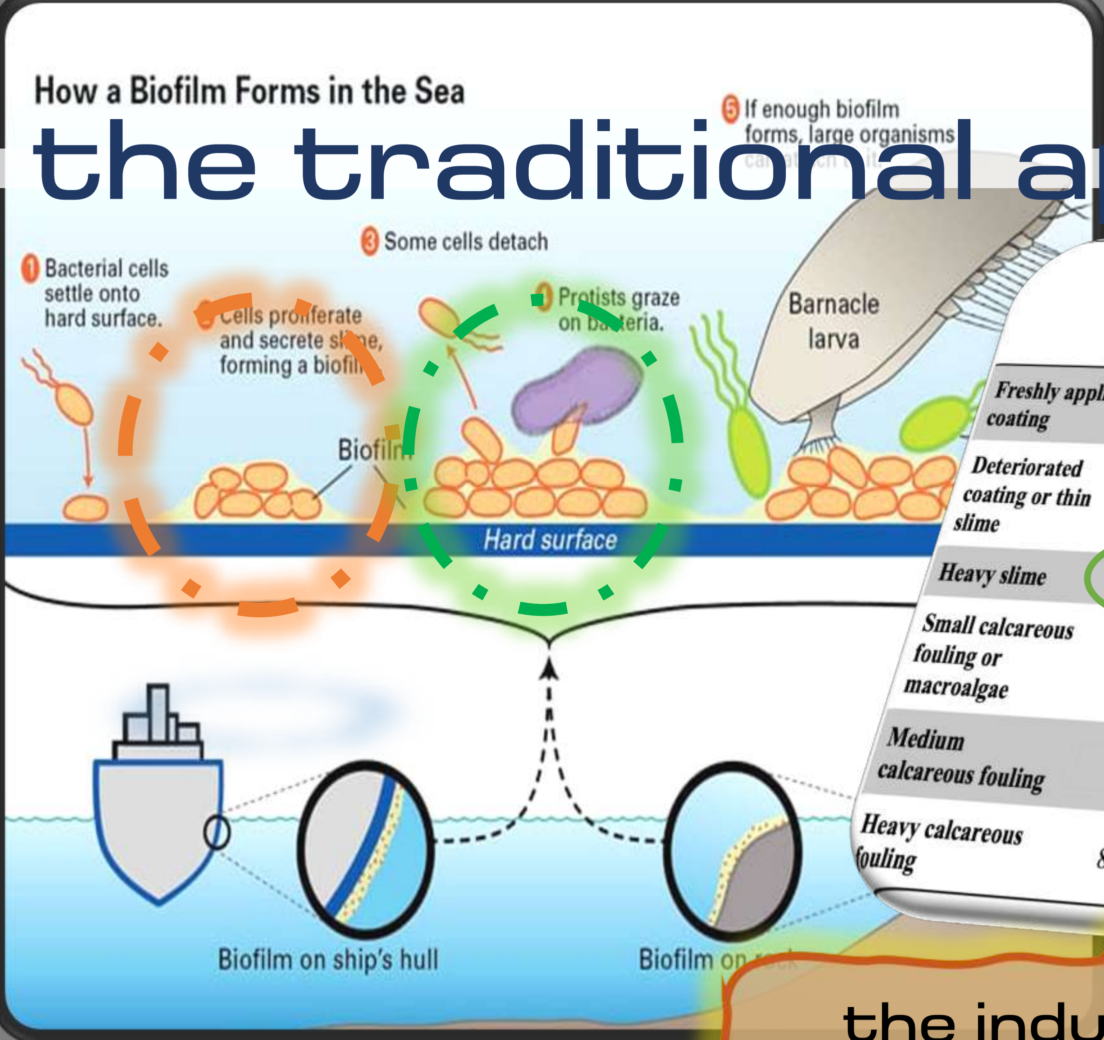
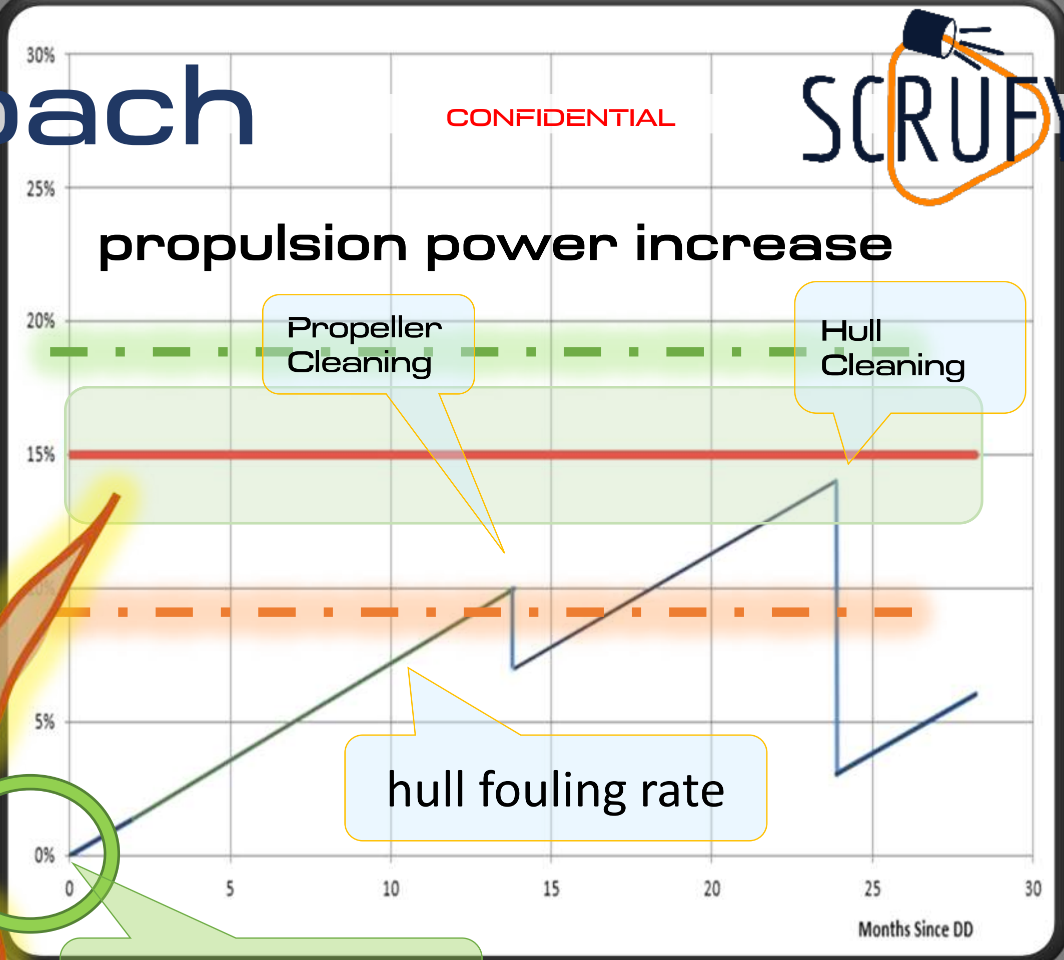


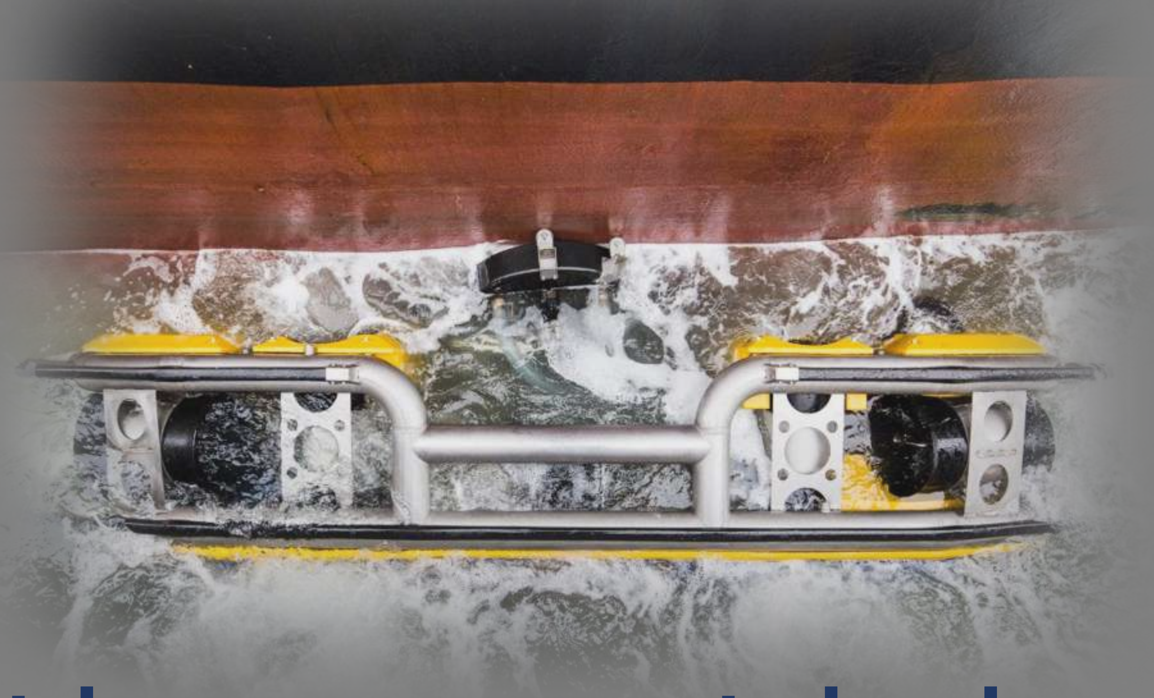
	Additional shaft power (%)	Ad in 2
Freshly applied coating	0	
Deteriorated coating or thin slime	9	44
Heavy slime	19	92
Small calcareous fouling or macroalgae	33	160
Medium calcareous fouling	52	253
Heavy calcareous fouling	84	408



the industry performance target

ship design

[4] International Maritime Organization – MEPC 60/4/21



the current industry

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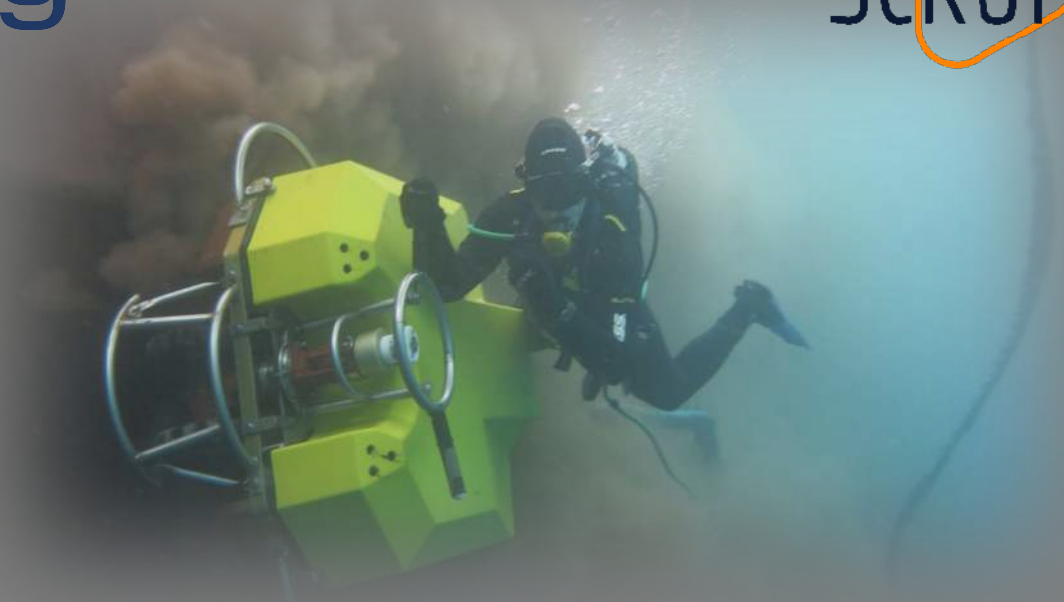

the current industry

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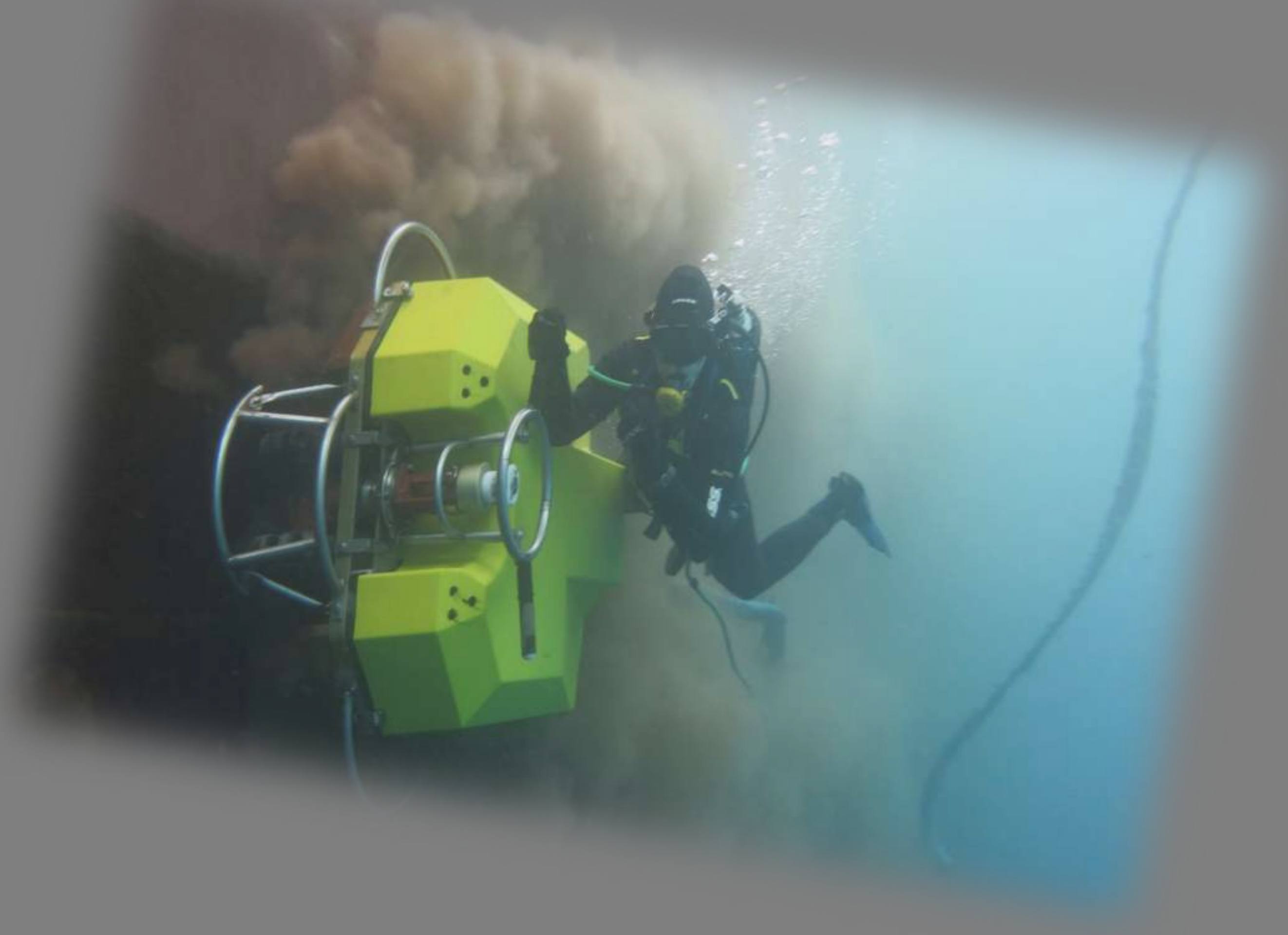

- poses safety concerns to the human operator
- uses abrasive brushes which add micro plastic[5] into the water column
- result in damage to the antifouling surface
- ports prohibition on hull cleaning aim partly to eliminate invasive species, biocides and paint particles

[5] *IMO (2019), Hull scrapings and marine coatings as a source of microplastics, Int. Maritime organisation, London*

the current industry

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ROV in-water cleaning stations are only offered in a few locations around the world

and

there is an increasing tendency for coastal and port states to place rules which prohibit the service

the traditional approach

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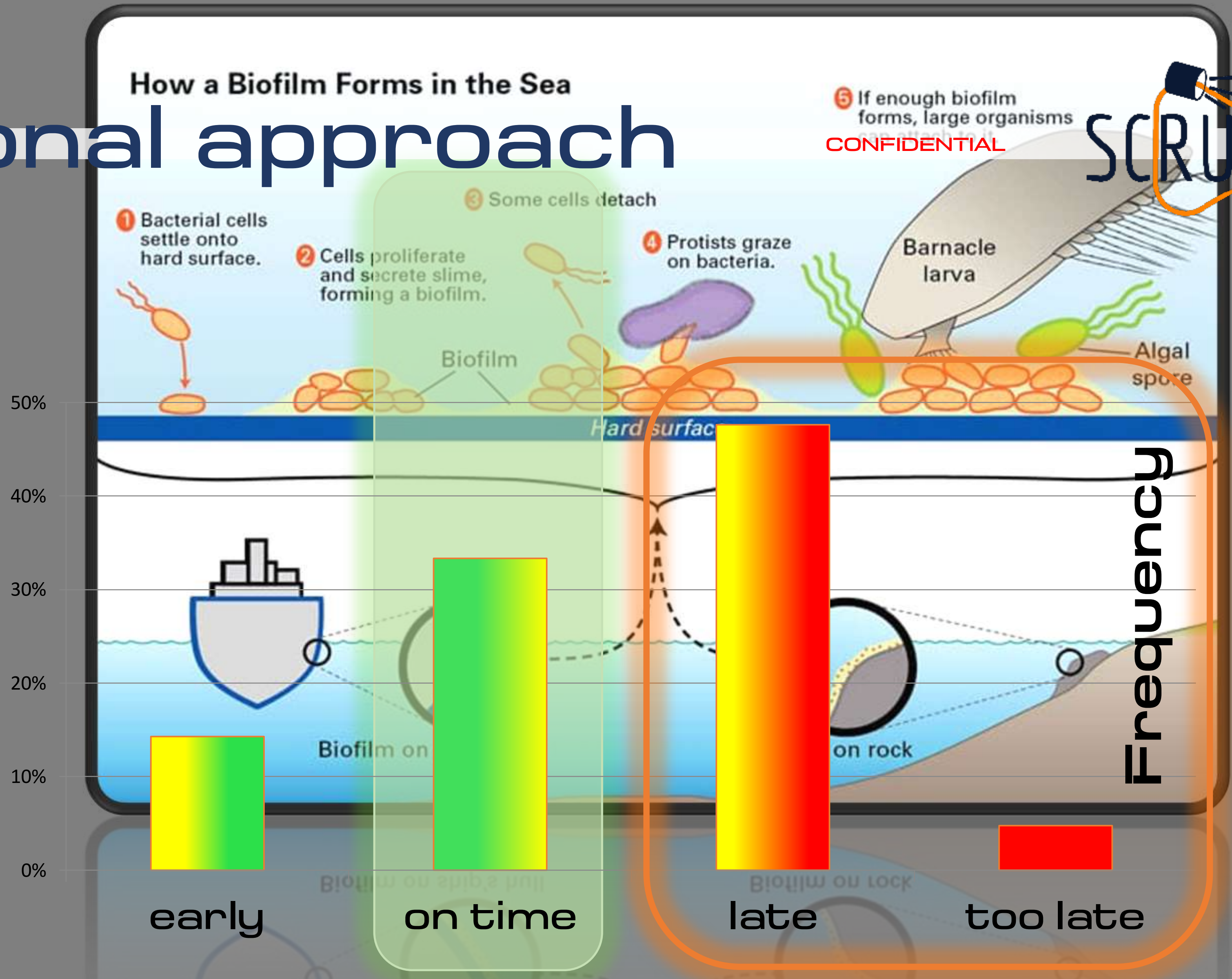
the current primitive industry performance norm



the answer

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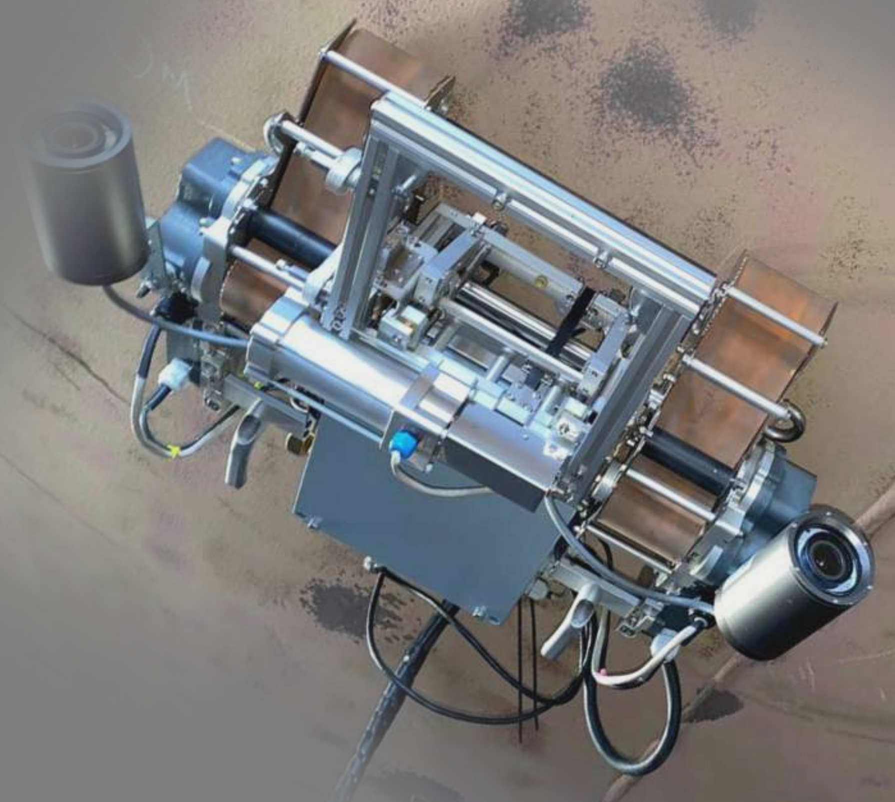
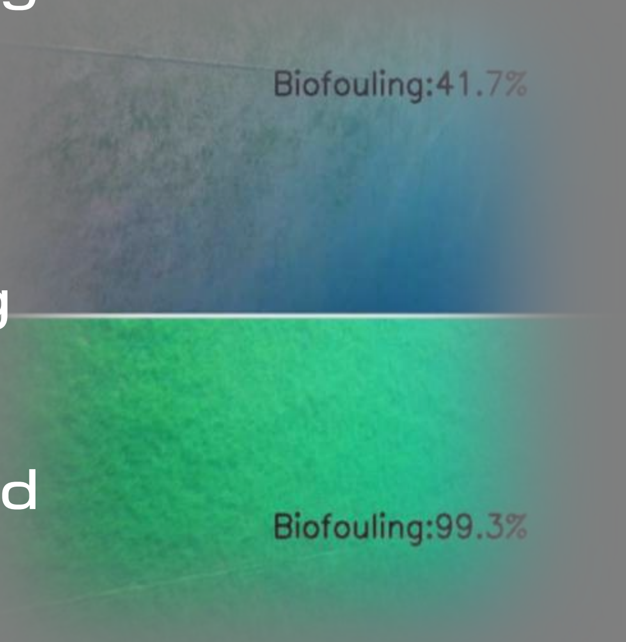


our Energy Saving Device (ESD)

addressing the carbon intensity of the vessel – by providing optimum hull performance

an integral part of each and every ship performing

autonomous and continuous monitoring and hull grooming



the answer

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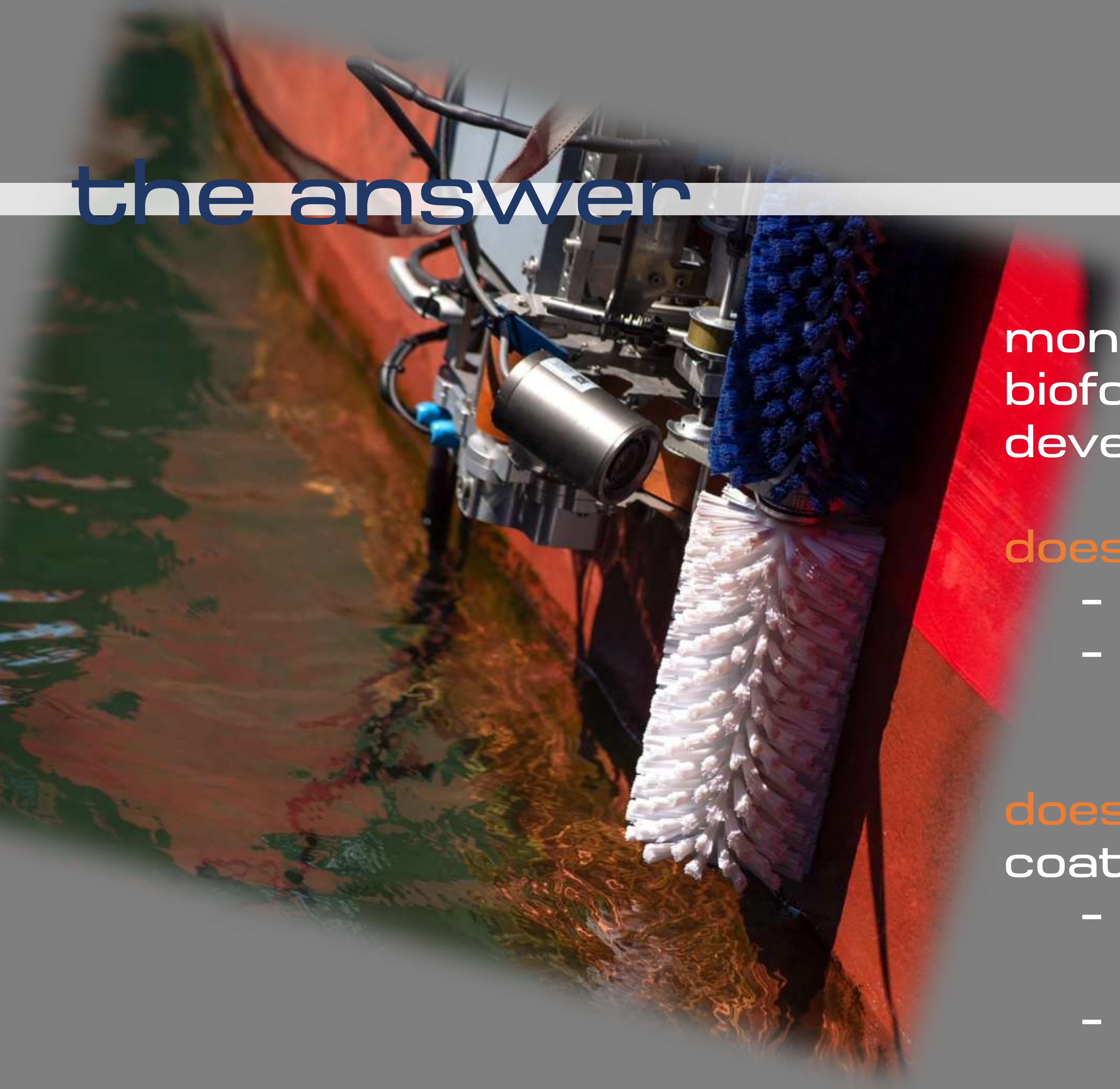


monitoring and effectively addressing biofouling in the micro stages of development..

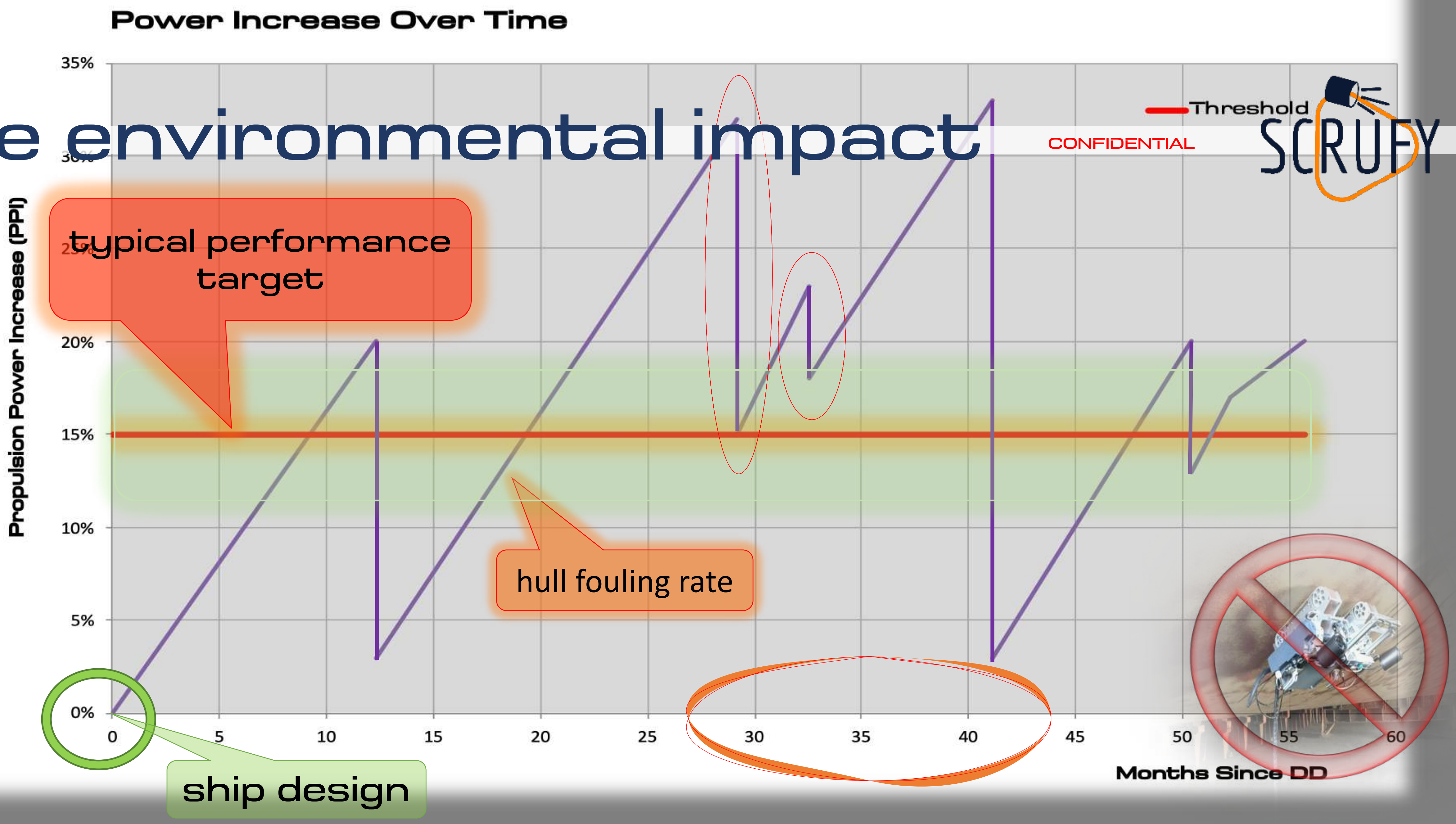
does not require capture and disposal:

- no risk of invasive species
- no risk from biocide release from the coating

does act in synergy with the hull coatings:

- removes silt, organics and incipient micro fouling
- maintains the coating function

the environmental impact



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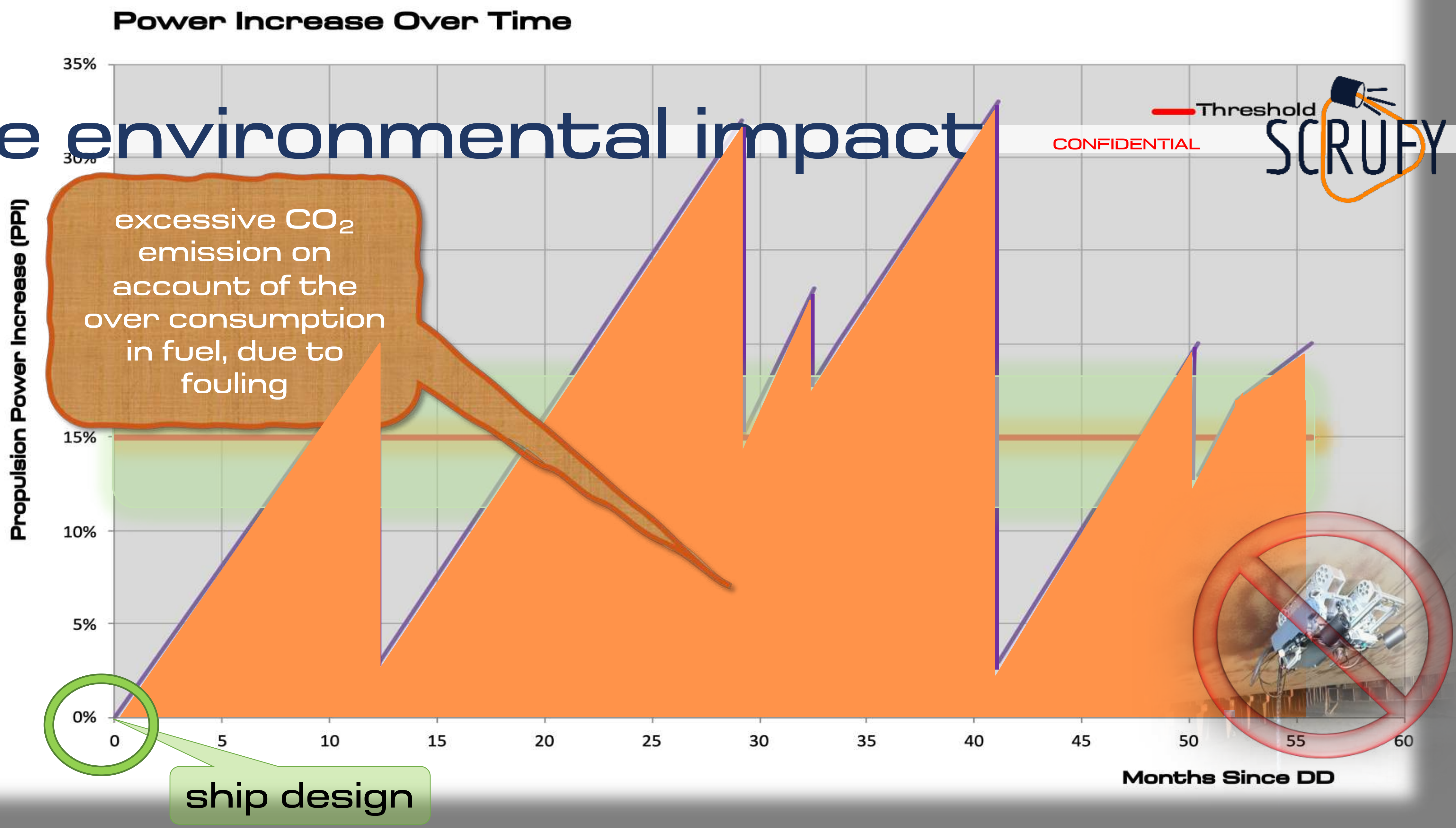
the environmental impact



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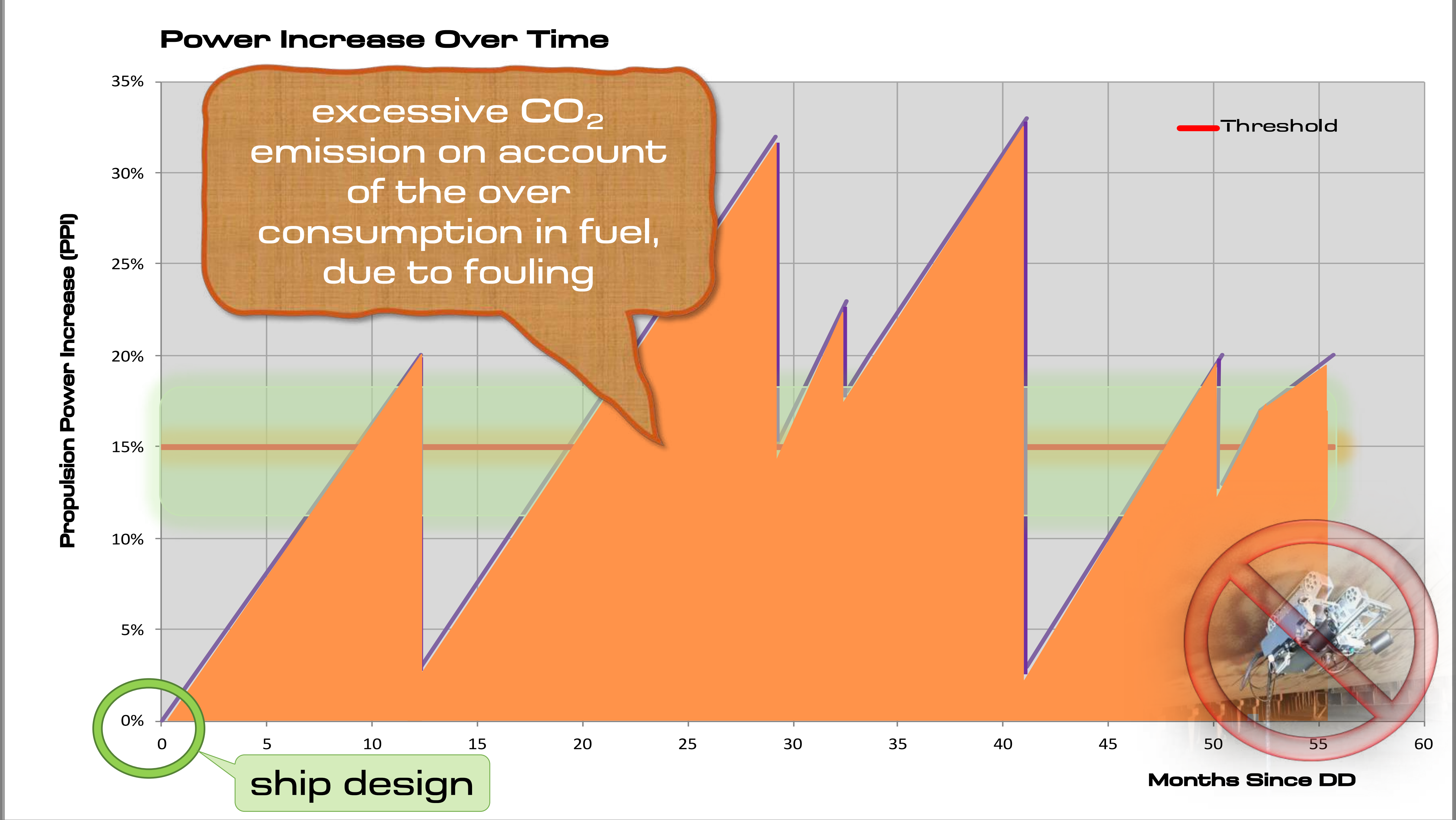

Power Increase Over Time
excessive CO_2 emission on account of the over consumption in fuel, due to fouling
Threshold
Propulsion Power Increase (PPI)
35%
30%
25%
20%
15%
10%
5%
0%
0
5
10
15
20
25
30
35
40
45
50
55
60
Months Since DD
ship design

we address the source

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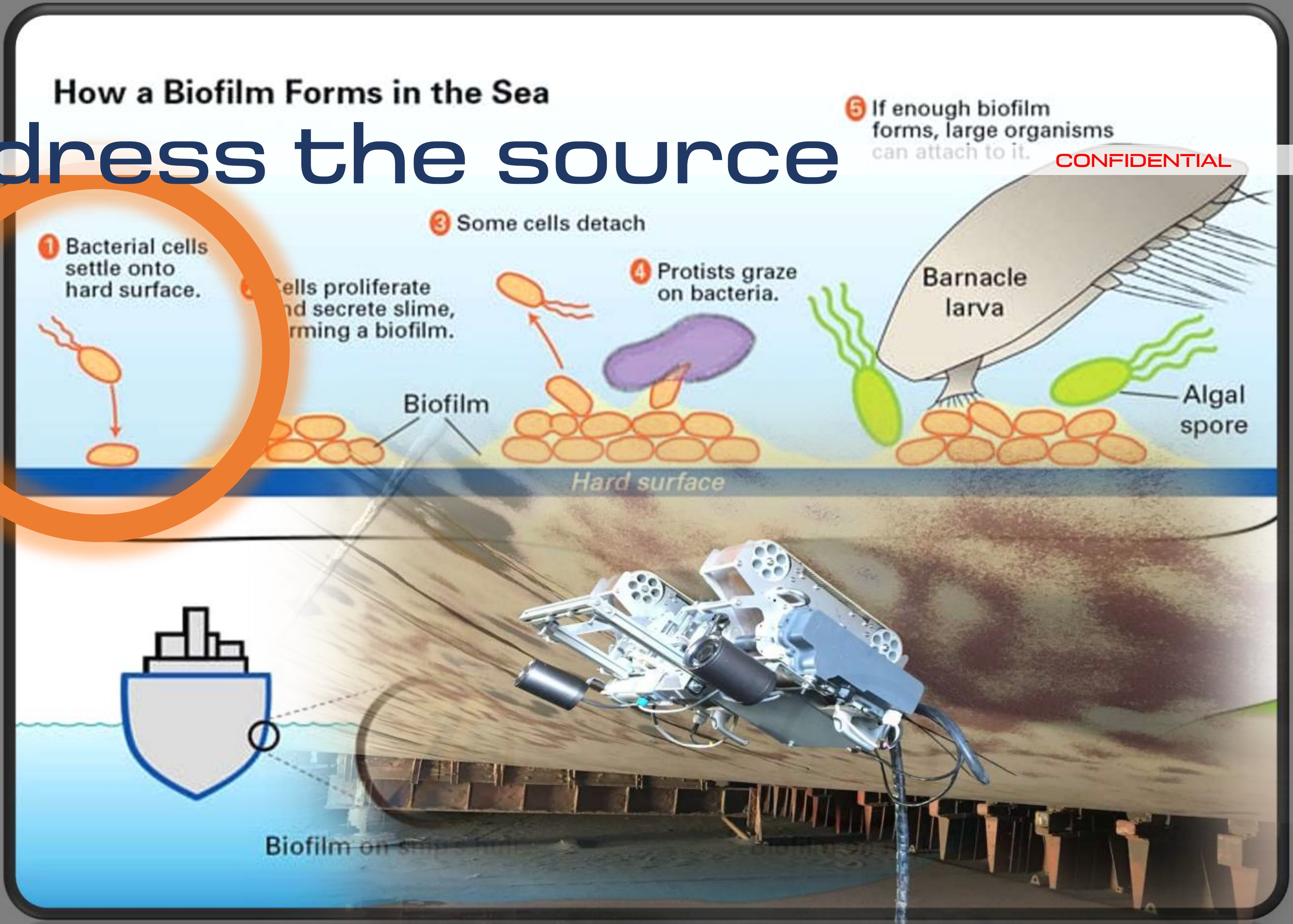

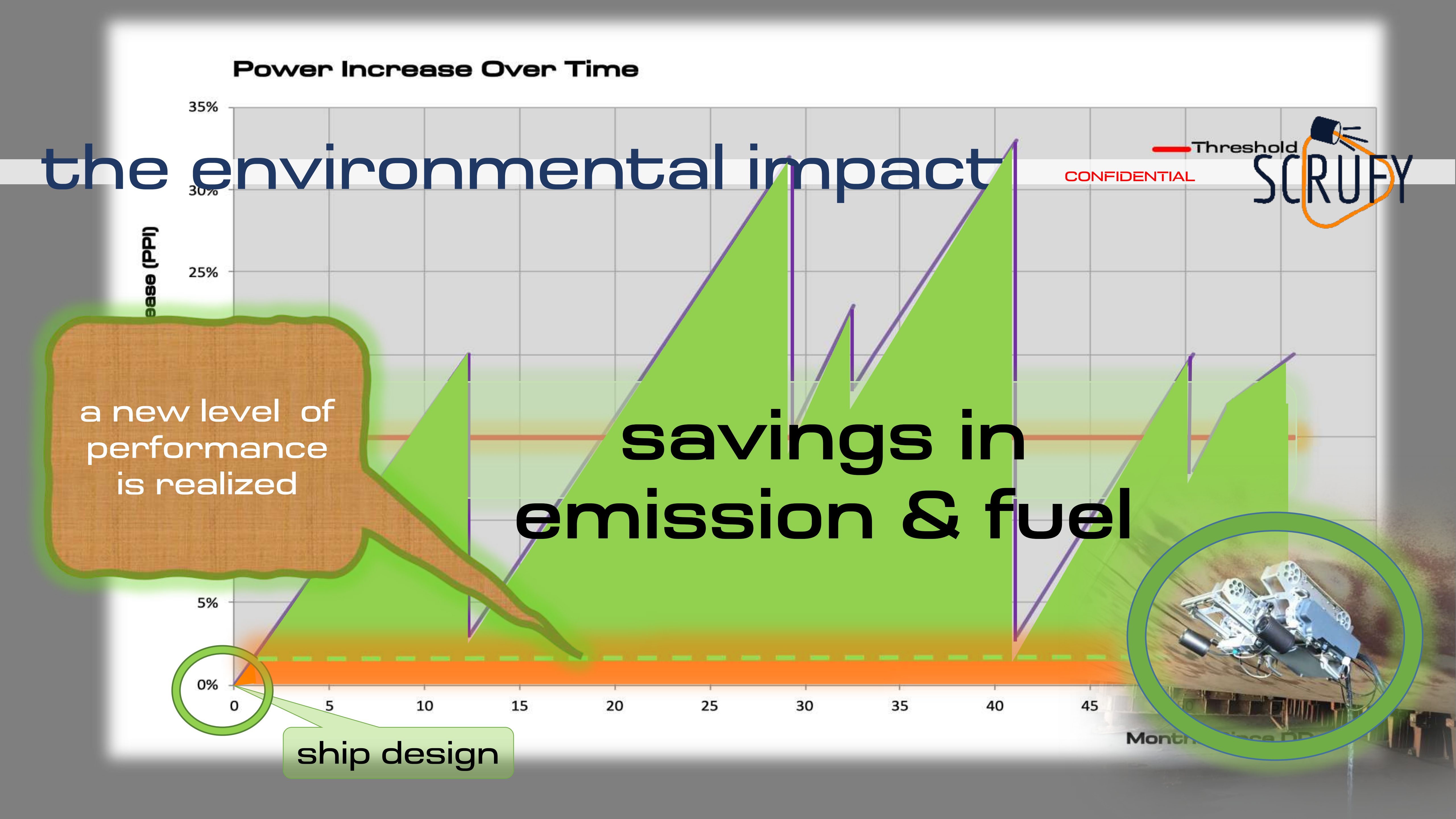

the environmental impact
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Power Increase Over Time
Threshold
35%
30%
25%
5%
0%
0
5
10
15
20
25
30
35
40
45
a new level of performance is realized
savings in emission & fuel
ship design

the impact

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$1.3M

Savings per vessel every
5-year cycle

- Fuel surplus
  3% to 15% PPI -> $1.1M
- AF paint savings
  -> ~$100K
- Hull treatment
  -> ~$100K
- Diver hull cleaning fees
  4 HC x $20K each -> ~$80K

2,500 mt GHG

Average Savings per vessel per year

- Reducing the Carbon Intensity Index (CII) of the Shipping Industry.
- To be included in the EU ETS from Jan 1st 2022.
- May reduce up to 5,300 mt of CO_2 per vessel per year.

400K lives

Saved yearly

- Accounted to poor air quality due to international shipping
- Annual cost to society in excess of $58Bn *

* European Federation of Transport and Environment

the competition

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Company	Product	Self-navigating	Operation when ship is underway	Biofouling quantification reporting	Preventive fouling removal
SCRUFY	**Scrufy**	√	X	√	√
JOTUN	Hull Skater	X	X	√	√
SHIPSHAVE	ITCH	X	√	X	√
HullWiper	HullWiper	X	X	√	X
FLEET CLEANER ROBOTIC UNDERWATER SERVICES	FleetCleaner	X	X	√	X

proof of concept

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prototype testing carried out on Nov' 2019

proof of concept

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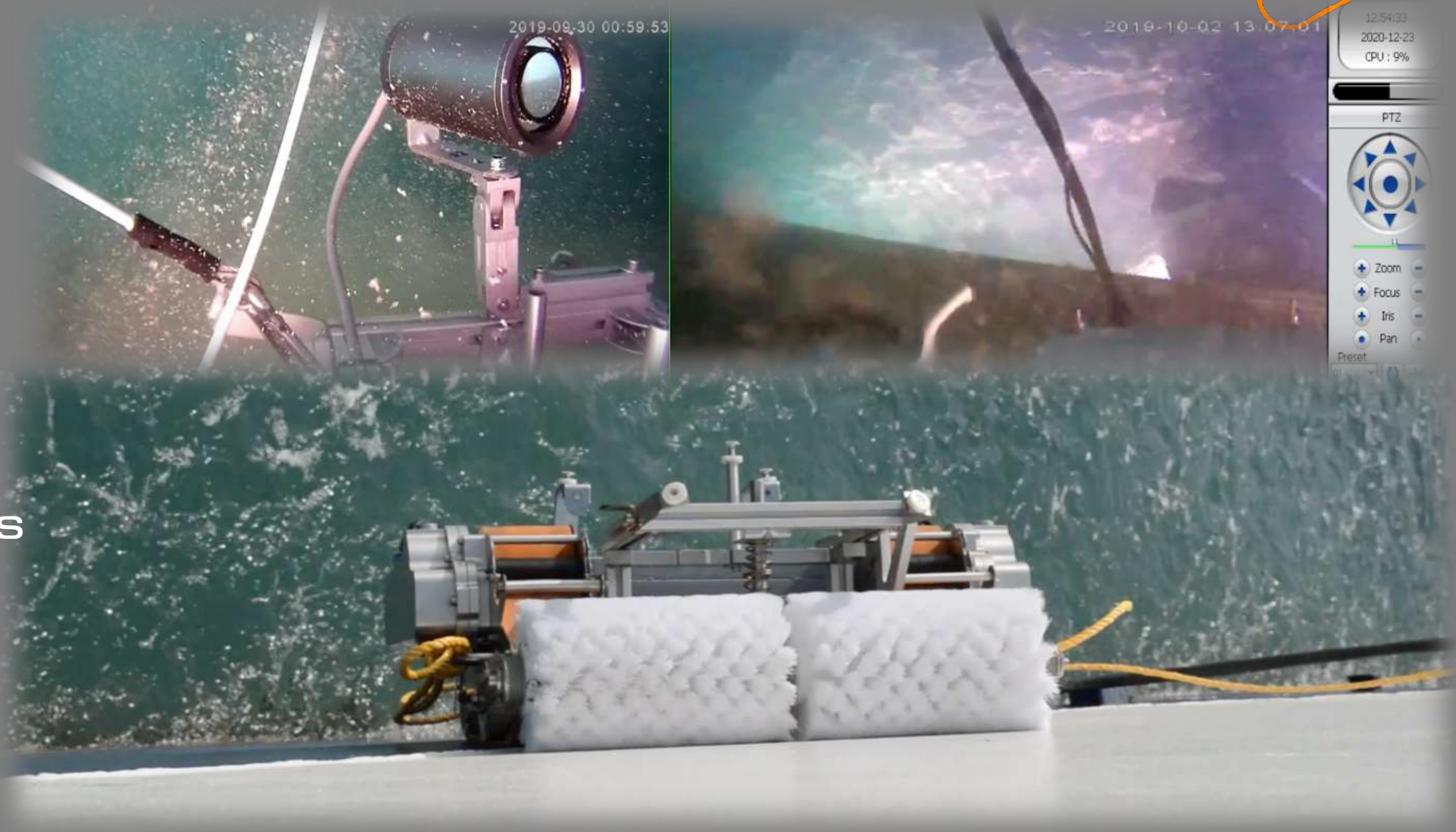
- multiple pilot grooming operations carried out underwater
- removed established levels of biofouling successfully



the market validation

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Product presentation was carried out on the 5th of March 2020, where Energy Managers representing a fleet of ~1,100 ships, attended.

seanergy

TSAKOS Group

ARCADIA SHIPMANAGEMENT CO. LTD

TRAFIGURA

MINERVA MARINE Inc.

PTM

DIANA WILHELMSEN Management Limited

BSM

THENAMARIS

the market validation

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synergies

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SCRUFY

BIOPASS

IKH

NanoPhos
Pioneering Nanotechnology

DIVING STATUS
UNDERWATER SERVICES

DNV·GL
BUSINESS ASSURANCE

TECHNAVA S.A.

demo carried out

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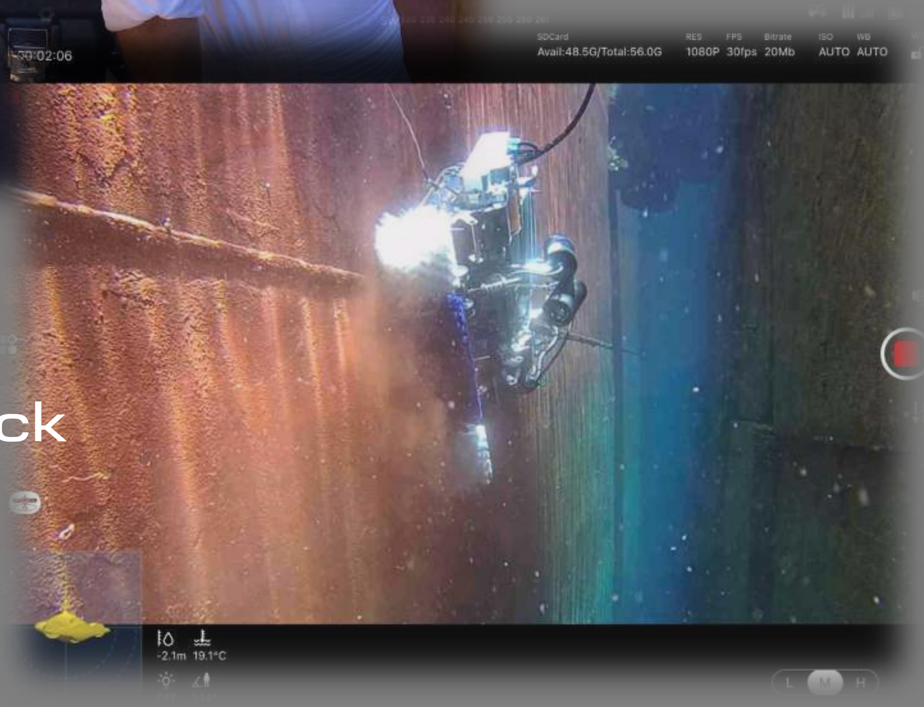
the main functionalities demonstrated:

- magnetic attachment to hull
- hull surface engagement by soft rubber bands for coating protection
- biofouling removal - at the level of slime (<FR20)
- easy installation on vessel's weather deck and safety recovery
- operation in accordance with safety procedures for the vessel and crew



the industry traction

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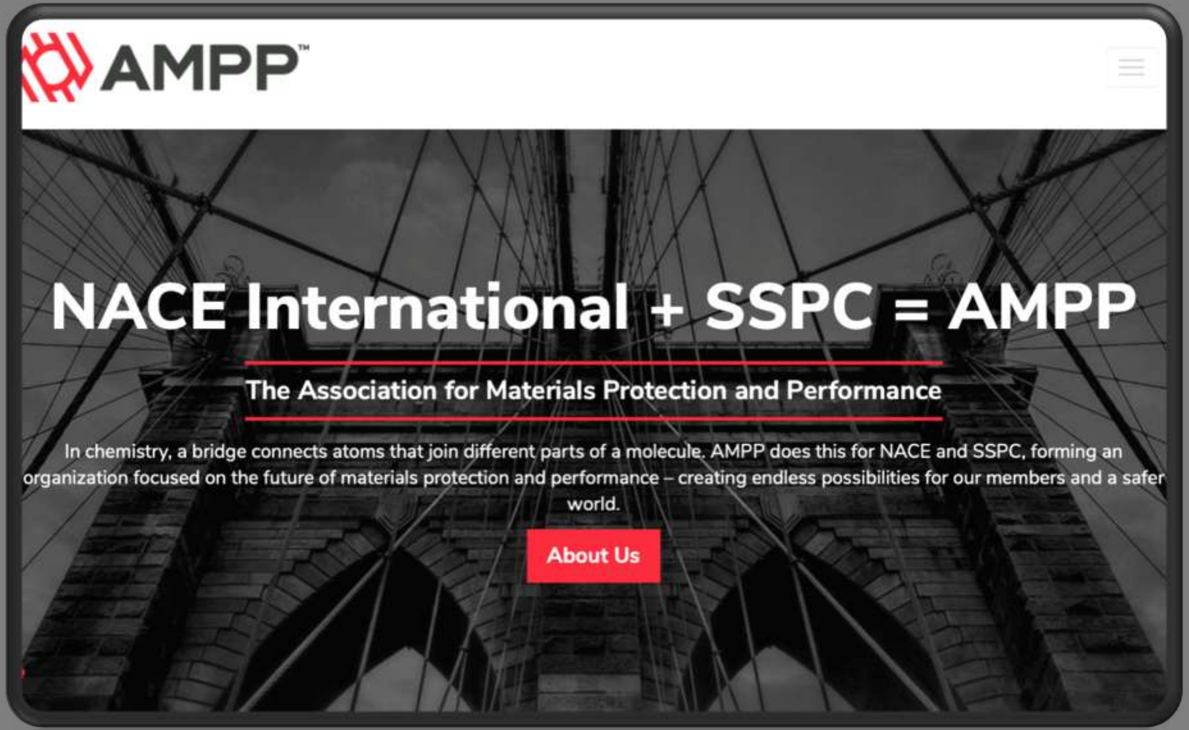

we are honoured to be invited to participate in a working group for the industry, by the Association for Materials Protection and Performance (AMPP)

to produce a technical report (TR) on robots, to establish the grooming and classification requirements of in-water survey, to allow such devices to provide for extension of the ship's dry dock interval, to 10 years.

the industry traction

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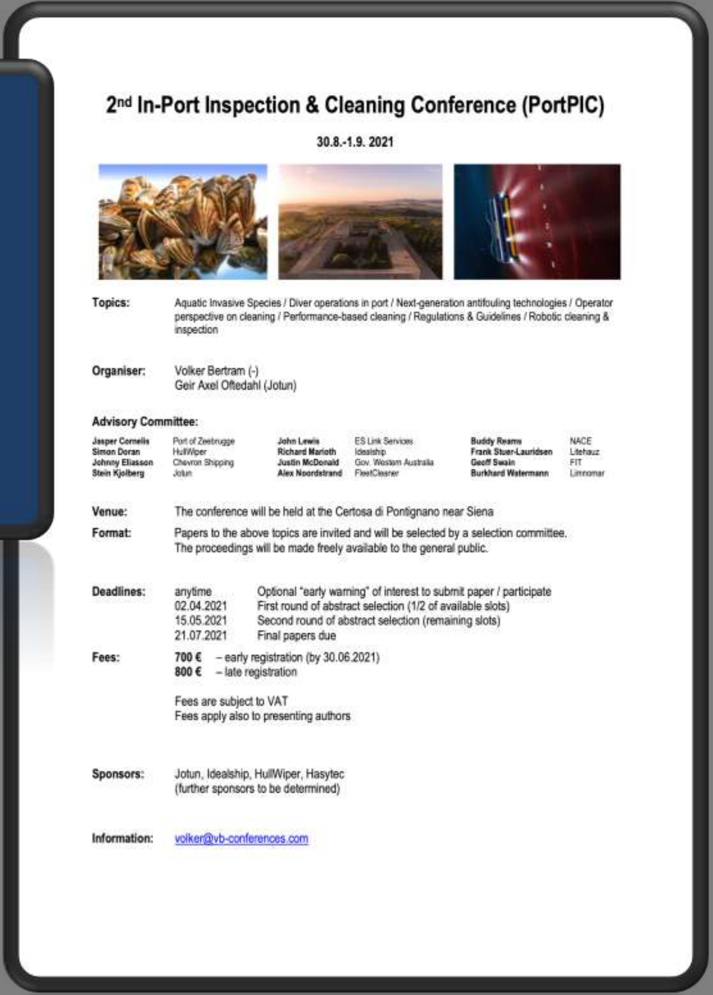

2nd In-Port Inspection & Cleaning Conference (PortPIC)

30.8.-1.9. 2021

Topics: Aquatic Invasive Species / Diver operations in port / Next-generation antifouling technologies / Operator perspective on cleaning / Performance-based cleaning / Regulations & Guidelines / Robotic cleaning & inspection

Organiser: Volker Bertram (-)
Geir Axel Oftedahl (Jotun)

Advisory Committee:

Jasper Cornelis	Port of Zeebrugge	**John Lewis**	ES Link Services	**Buddy Reams**	NACE
Simon Doran	HullWiper	**Richard Marioth**	Idealship	**Frank Stuer-Lauridsen**	Litehauz
Johnny Eliasson	Chevron Shipping	**Justin McDonald**	Gov. Western Australia	**Geoff Swain**	FIT
Stein Kjolberg	Jotun	**Alex Noordstrand**	FleetCleaner	**Burkhard Watermann**	Limnomar

Venue: The conference will be held at the Certosa di Pontignano near Siena

Format: Papers to the above topics are invited and will be selected by a selection committee. The proceedings will be made freely available to the general public.

Deadlines:

anytime	Optional "early warning" of interest to submit paper / participate
02.04.2021	First round of abstract selection (1/2 of available slots)
15.05.2021	Second round of abstract selection (remaining slots)
21.07.2021	Final papers due

Fees: **700 €** – early registration (by 30.06.2021)
800 € – late registration

Fees are subject to VAT
Fees apply also to presenting authors

Sponsors: Jotun, Idealship, HullWiper, Hasytec
(further sponsors to be determined)

Information: volker@vb-conferences.com

we are honoured to have been invited to present this innovative solution at the 2nd PortPIC Conference

Aug' 2021

@ In-Port Inspection & Cleaning Conference (PortPIC) driven by DNV GL

App. I ESD Cost Benefit Analysis

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presentation: 20 May 2021

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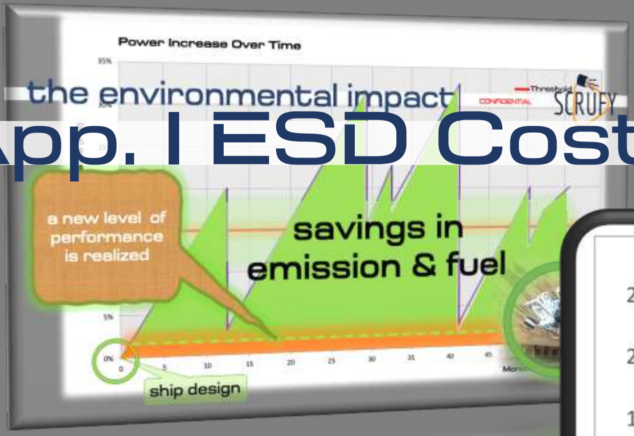

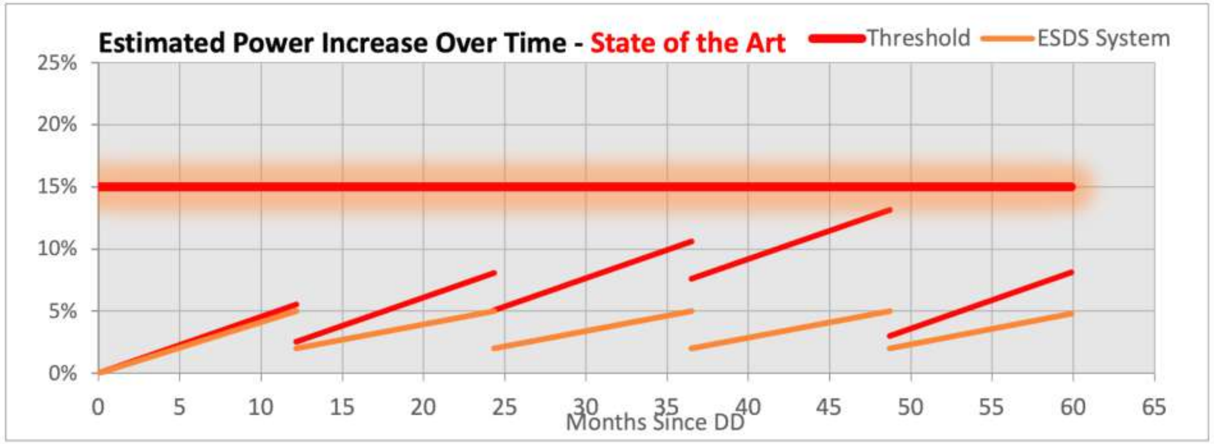

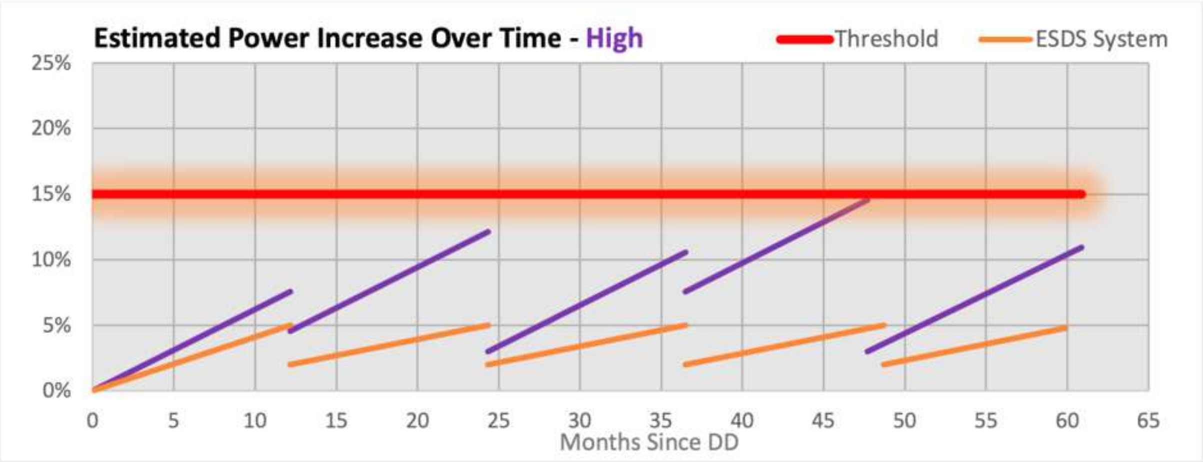

App. I ESD Cost Benefit Analysis

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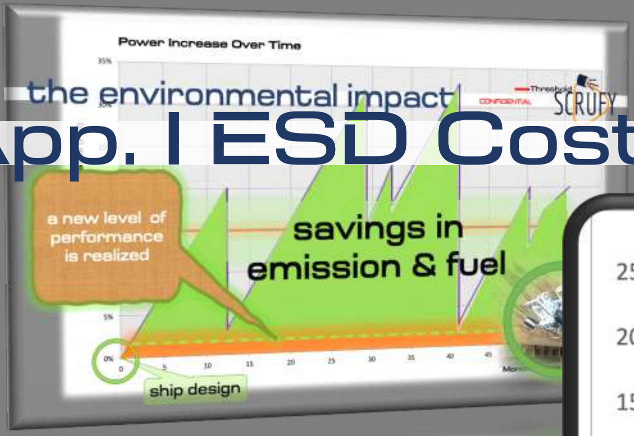
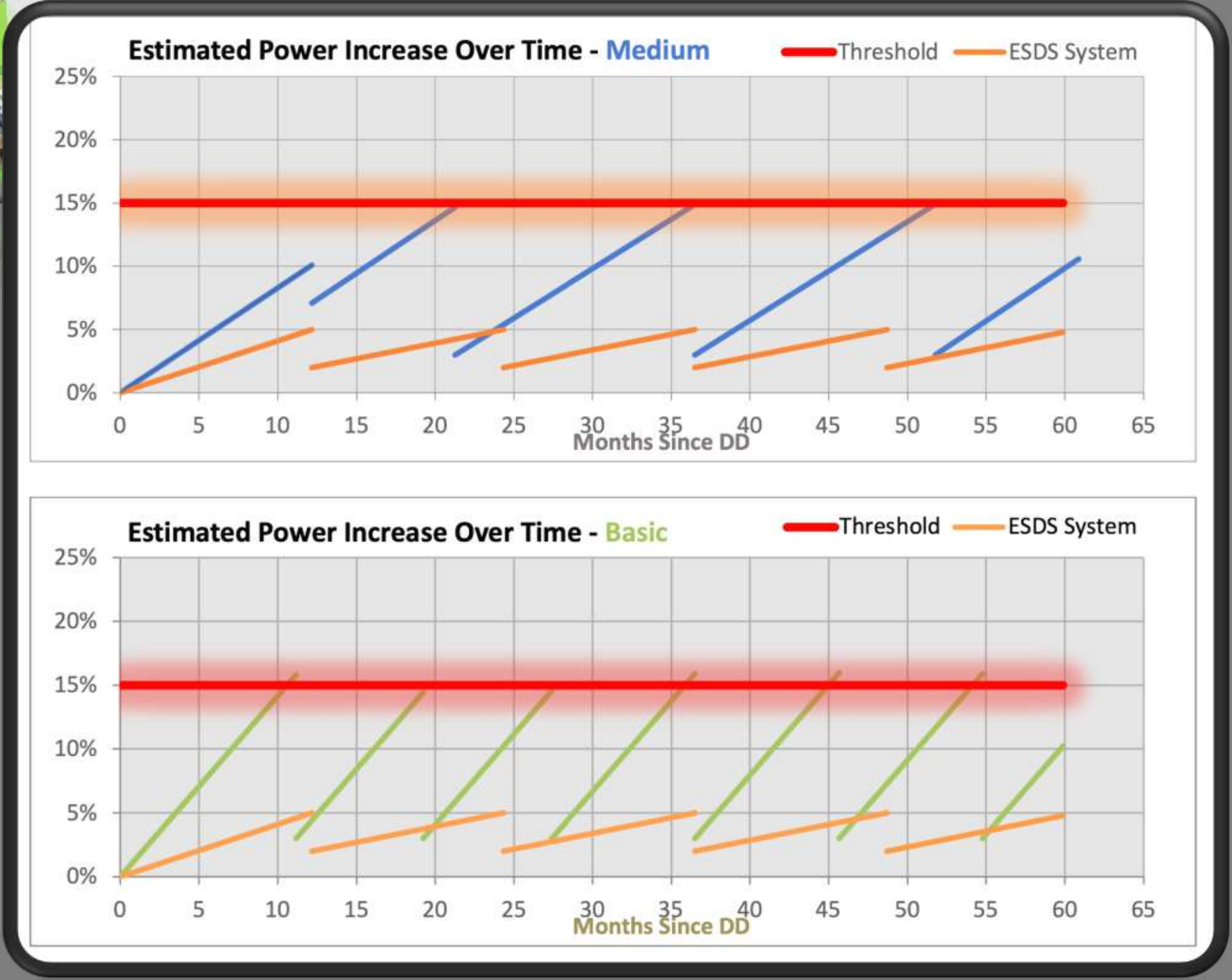
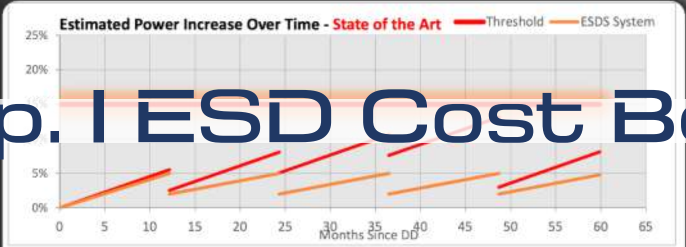
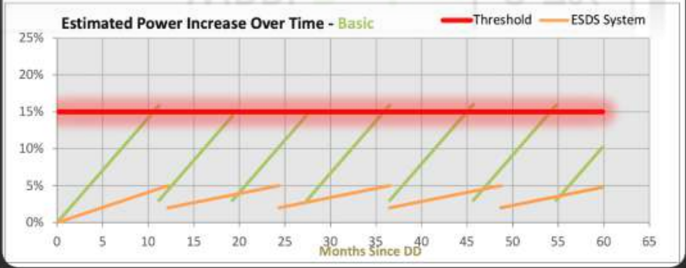




App. I ESD Cost Ber



WPPI ESD[3]:	3.3%
WPPI State of the Art:	6.4%
WPPI High:	7.3%
WPPI Medium:	8.1%
WPPI Basic:	8.7%



	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E	
AF System Type	Basic	Medium	High	State of the Art	ESD	Units
Add. Fuel Cost	1664.7	1550.3	1395.2	1216.4	624.5	K U$
AF System Cost	73.4	87.3	105.8	129.2	73.4	K U$
UW Cost	129.0	68.0	50.0	32.0	14.0	K U$
ESD Cost	-	-	-	-	160.0	K U$
Excess CO_2 Emissions	17,281.4	16,094.4	14,484.2	12,627.8	6,482.9	MT of CO_2
Grand Total	**1867.0**	**1705.6**	**1551.0**	**1377.6**	**871.8**	K U$
Savings, U$	**0.0**	**161.4**	**316.0**	**489.5**	**995.2**	K U$
Savings, CO_2	-	**1,187.0**	**2,797.2**	**4,653.6**	**10,798.5**	MT of CO_2
OPEX	**29.9**	**27.0**	**24.1**	**20.8**	**10.6**	K U$/month
Payback Period to Basic	-	4.8	5.6	6.1	8.3	months
Payback Period to Medium	-	-	6.4	6.8	9.1	months
Payback Period to High			-	7.1	9.8	months
Payback Period to State of the Art	-	-	-	-	10.9	months

TABLE ONE. TABULATED COST(S) INDICATIVE OF (A) THE SAVINGS BETWEEN SELECTION OF COATING TYPE, (B) RELATIVE EFFECT ON EMISSIONS AND (C) ASSOCIATED RETURN ON INVESTMENT - INCLUSIVE THE SETTLEMENT OF THE ESD, FOR SCENARIO E.

[3] The PPI associated with the ESD, is attributed to the Propeller fouling.

App. I ESD Cost Benefit Analysis

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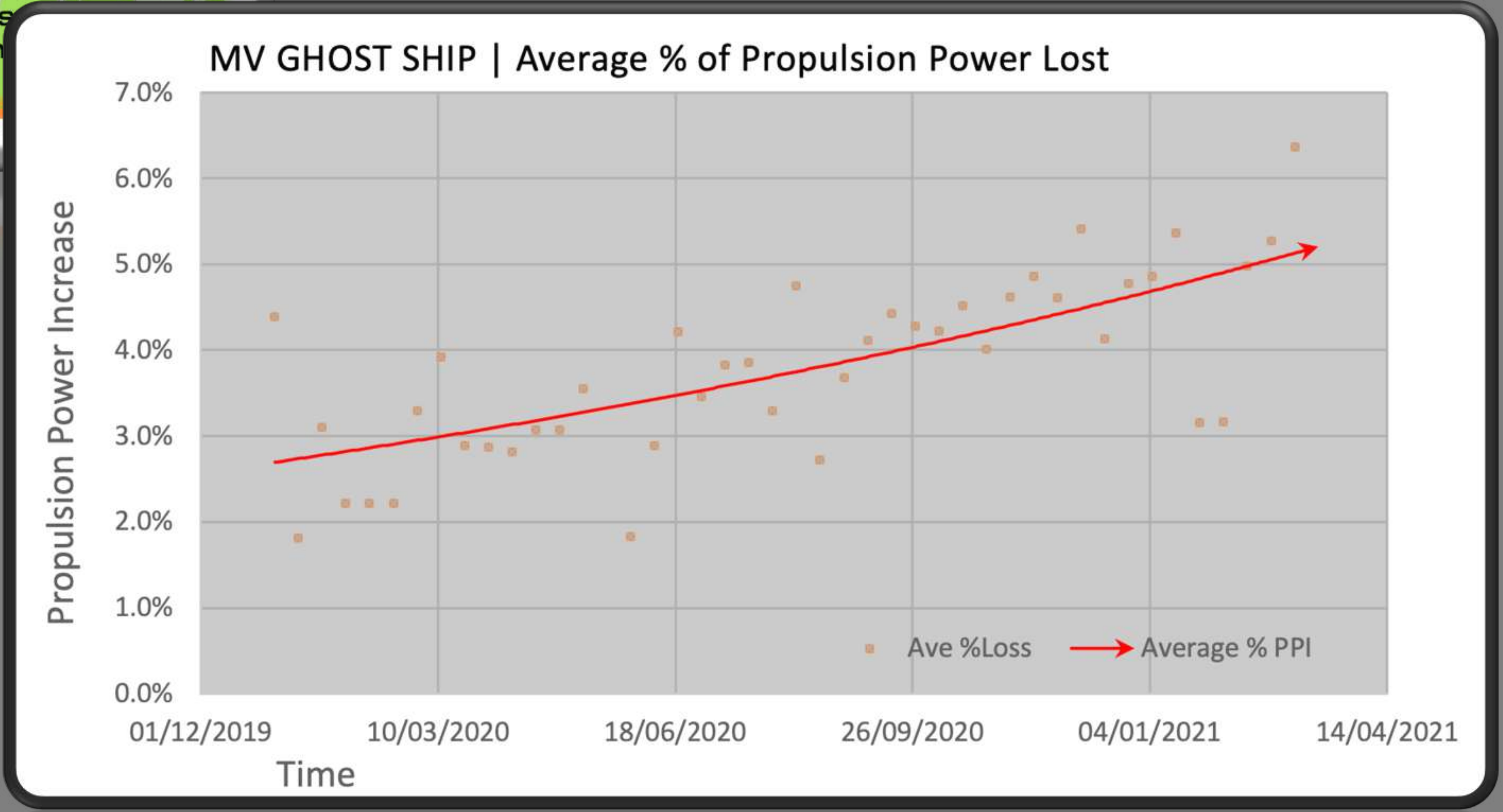

App. I ESD Cost Benefit Analysis

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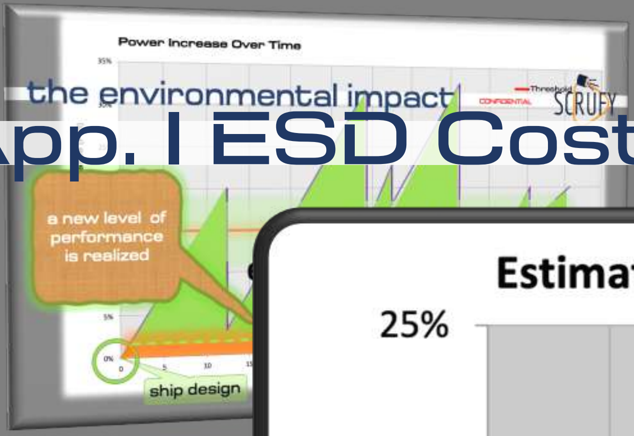

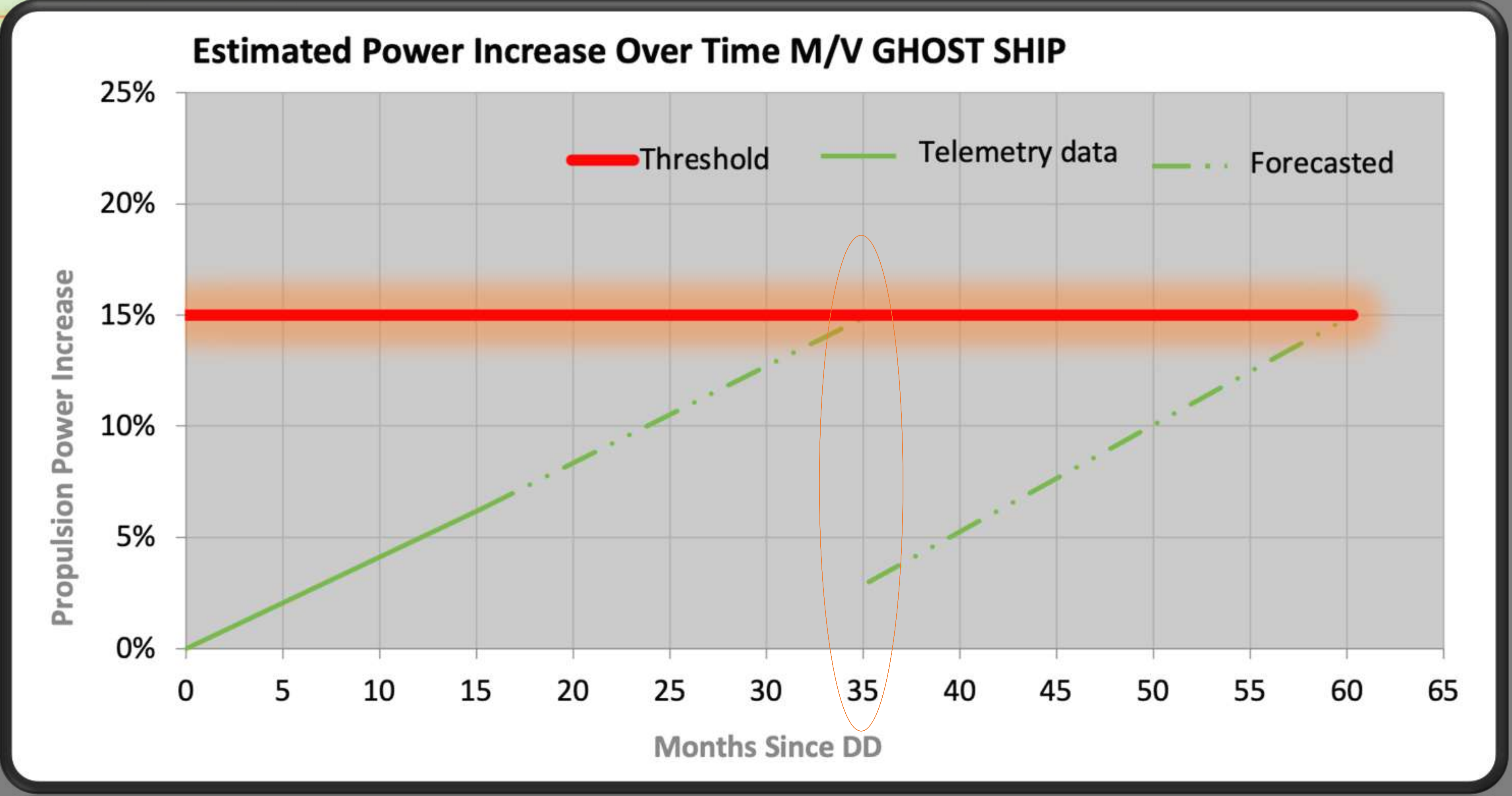

App. I ESD Cost Benefit Analysis

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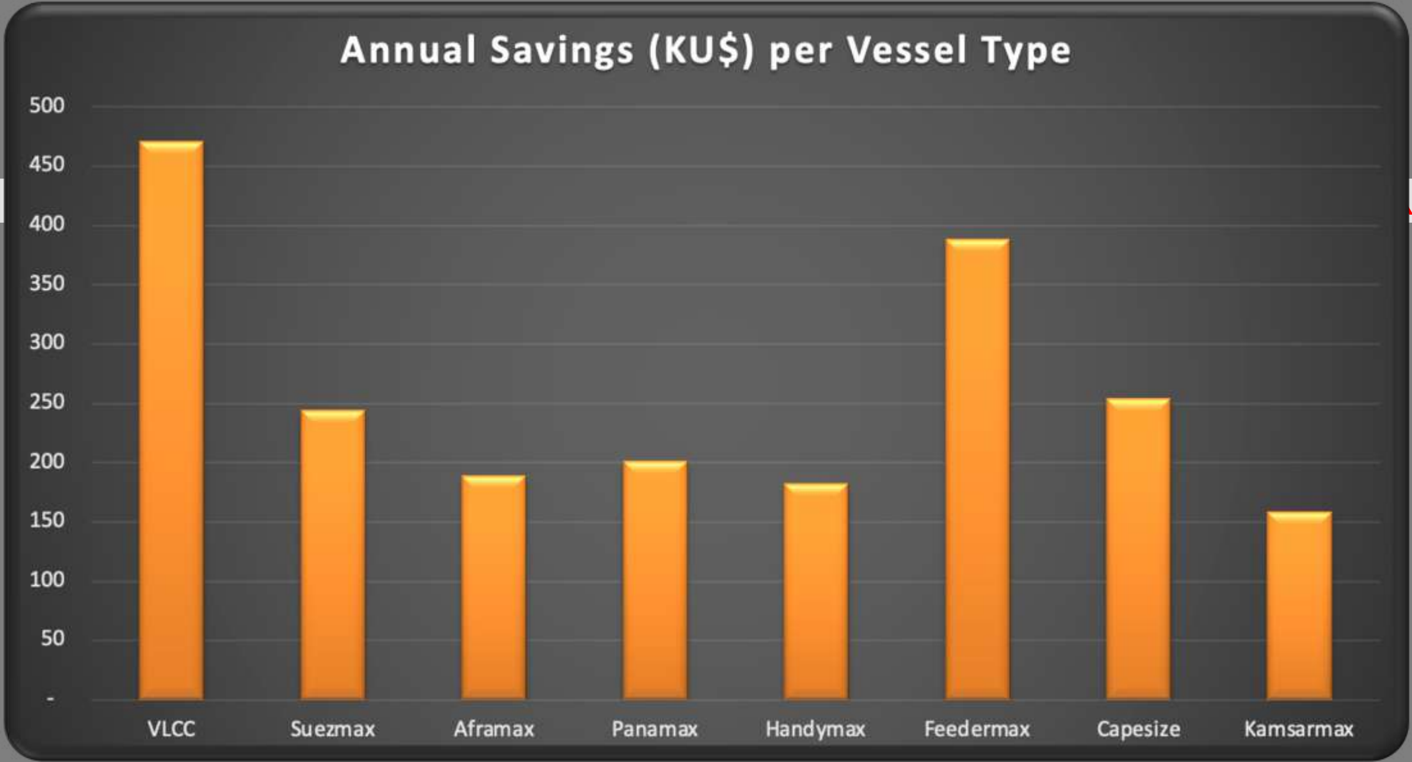
W	
WPPI State	
W	
WPP	
W	
Fue	
DD	
Condition	Speed
Ballast	1
Laden	1

	Actual/Forecasted	Scenario E	
System:	With Out ESD	**ESD**	Units
Add. Fuel Cost	1,536.3	624.5	K U$
AF System Cost	87.3	73.4	K U$
UW Cost	21.5	14.0	K U$
ESD Cost	-	-	K U$
Excess CO_2 Emissions	15,949.3	6,482.9	MT of CO_2
Grand Total	**1,645.1**	**711.8**	K U$
Savings, U$	**221.9**	**1,155.2**	K U$
Savings, CO_2	**1,332.1**	**10,798.5**	MT of CO_2
OPEX	**26.0**	**10.6**	K U$/month

TABLE THREE. TABULATED COST(S) INDICATIVE OF THE SUBSTANTIAL SAVINGS, FOR EACH DOCKING CYCLE, IN COMPARISON WITH BASIC AF SYSTEM SELECTION.

App. I ESD Cost



Type:	VLCC	Suezmax	Aframax	Panamax	Handymax	Feedermax	Capesize	Kamsarmax	Total	Average
5Y Savings (KU$):	2,355	1,222	945	1,006	913	1,944	1,271	795	91,906	1,107
No of Vsl:	2	15	18	12	20	6	4	6	83	10
Annual Savings (KU$):	471	244	189	201	183	389	254	159	18,381	221
Monthly Savings (KU$):	39	20	16	17	15	32	21	13	1,337	16

App. I.I ESD Effect on Charter FOC Table

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presentation: 20 May 2021

App. I.I ESD Effect on Charter FOC Table

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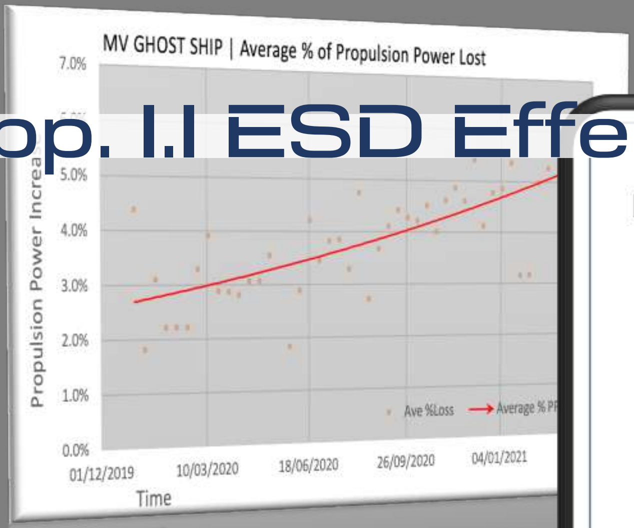
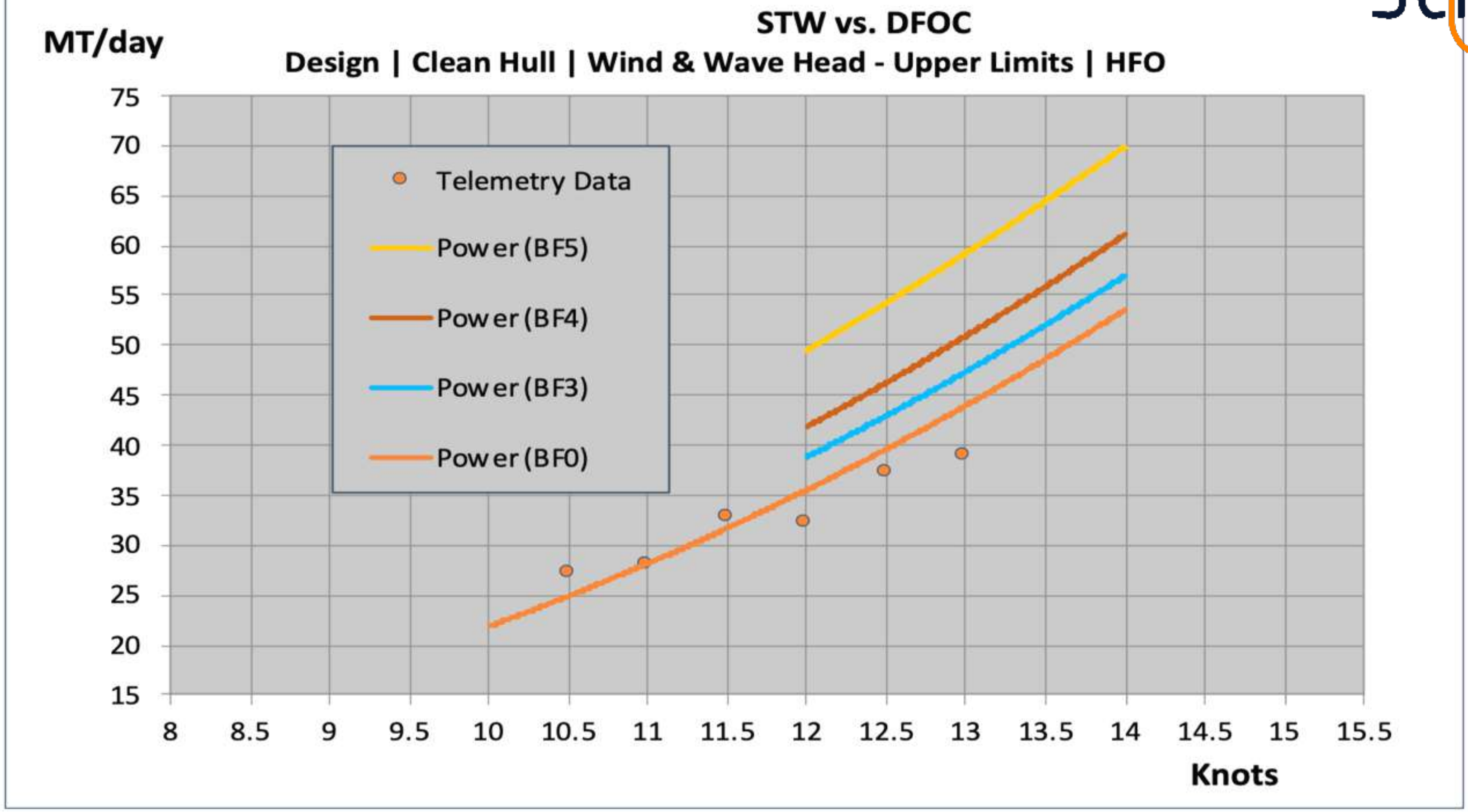
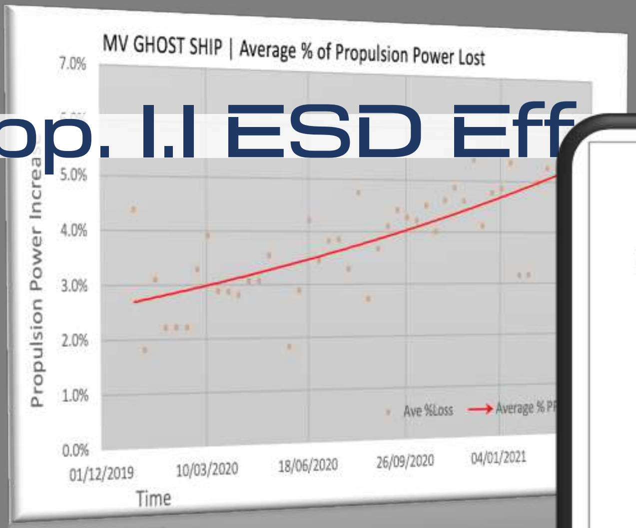
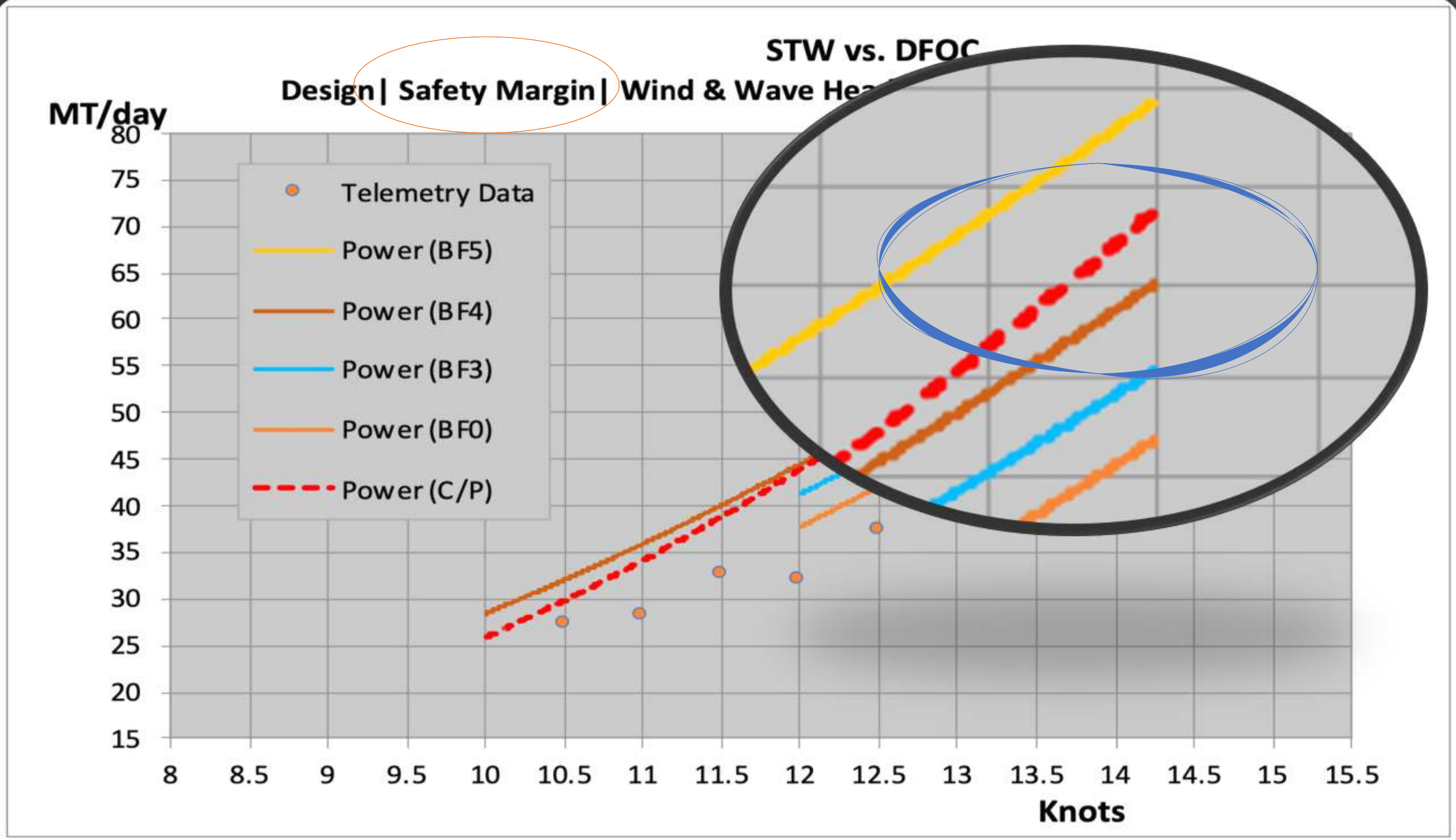




GRAPH ONE. DFOC TABLE PER SEA STATE - AS DERIVED FROM TELEMETRY DATA.

App. I.I ESD Eff





GRAPH TWO. GRAPHICAL REPRESENTATION OF THE APPLICATION OF THE 'SAFETY MARGIN' ON THE C/P DFOC TABLE.

App. I.I ESD Effect on Charter FOC Table

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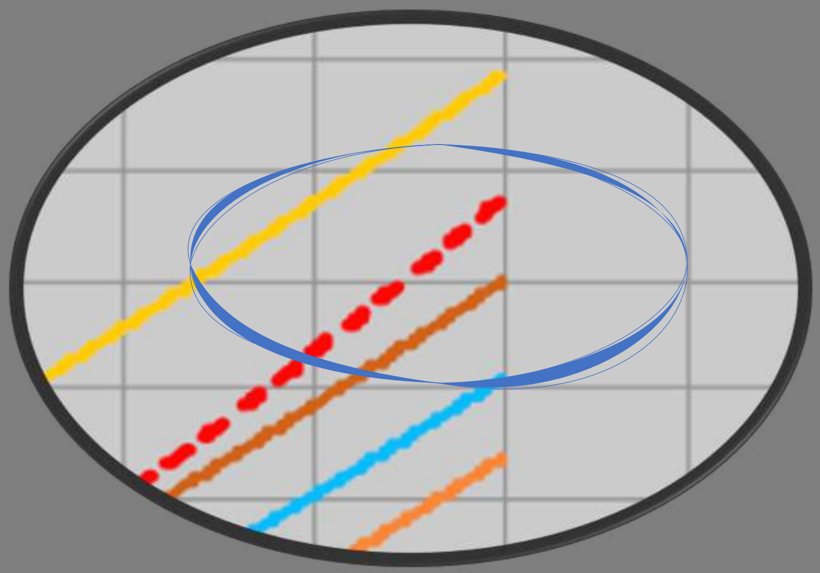

STW	CP DFOC with Safety Margin	CP DFOC with ESD	Δ%
10	25.7	26.7	-4%
11	34.2	33.8	1%
12	44.9	41.8	7%
12.5	49.2	46.3	6%
13	54.6	50.9	7%

TABLE **ONE**. INDICATIVE COMPETITIVE GAIN
WITH THE EMPLOYMENT OF THE ESD IN ATTRACTING THE CHARTER

technical specification

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content

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product description

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SCRUFY is a magnetic crawler for biofouling inspection and grooming of ship hulls.

it features soft tracks to prevent anti-fouling coating damage.

grooming is achieved with the soft polyamide brushes, at the stage of micro-fouling | slime.

ultra-high resolution cameras allow for remote fouling data acquisition and analysis through exclusively developed AI algorithms which map and quantify the level of fouling on the various parts of the hull.

product capabilities

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HULL GROOMING

In-Water Survey AS PER CLASS REQUIREMENTS

QUANTIFICATION OF BIOFOULING LEVEL

AUTONOMOUS MAPPING AND REPORTING OF BIOFOULING

NO DAMAGE OF ANTI-FOULING COATING

AUTONOMOUS NAVIGATION ON HULL BASED ON PRE-DEFINED PATH

product features

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- PLUG IN GROOMING HEADS
- 2 x UHD UNDERWATER CAMERAS FOR VISUAL INSPECTION
- MULTI - SPECTRAL CAMERA FOR BIOFOULING IDENTIFICATION IN MURKY AND TURBULANT WATERS
- IN - HOUSE DEVELOPED ALGORITHMS FOR AUTOMATED BIOFOULING QUANTIFICATION AND REPORTING
- INTELLIGENT LOCALISATION SYSTEM
- PATENT-PENDING MAGNETIC TRACK COMPOUND
- ADVANCED NAVIGATION ALGORITHMS
- VIDEO RECORDING OF GROOMING OPERATION
- USER FRIENDLY DEPLOYMENT AT ANCHORAGE

product specification

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Specification	Value | description
Overall Dimensions	L=732mm, W=605mm, H=255mm
Crawler Deployment Weight	65kg (incl. umbilical cord)
Maximum Inspection Moving Speed	30 m/min
Maximum Grooming moving speed	20 m/min
Grooming Width	800 mm
Input Voltage	230 VAC
Crawler Operating Voltage	48 VDC
Nominal Power	500 W
Maximum Intermittent current drawn	30 A
Cleaning method	Soft rotating polyamide brush
Operating temperature range	-20 – 50 °C
Compliance to curved surfaces	Concave and convex surfaces of ≥1 m radius

component specification

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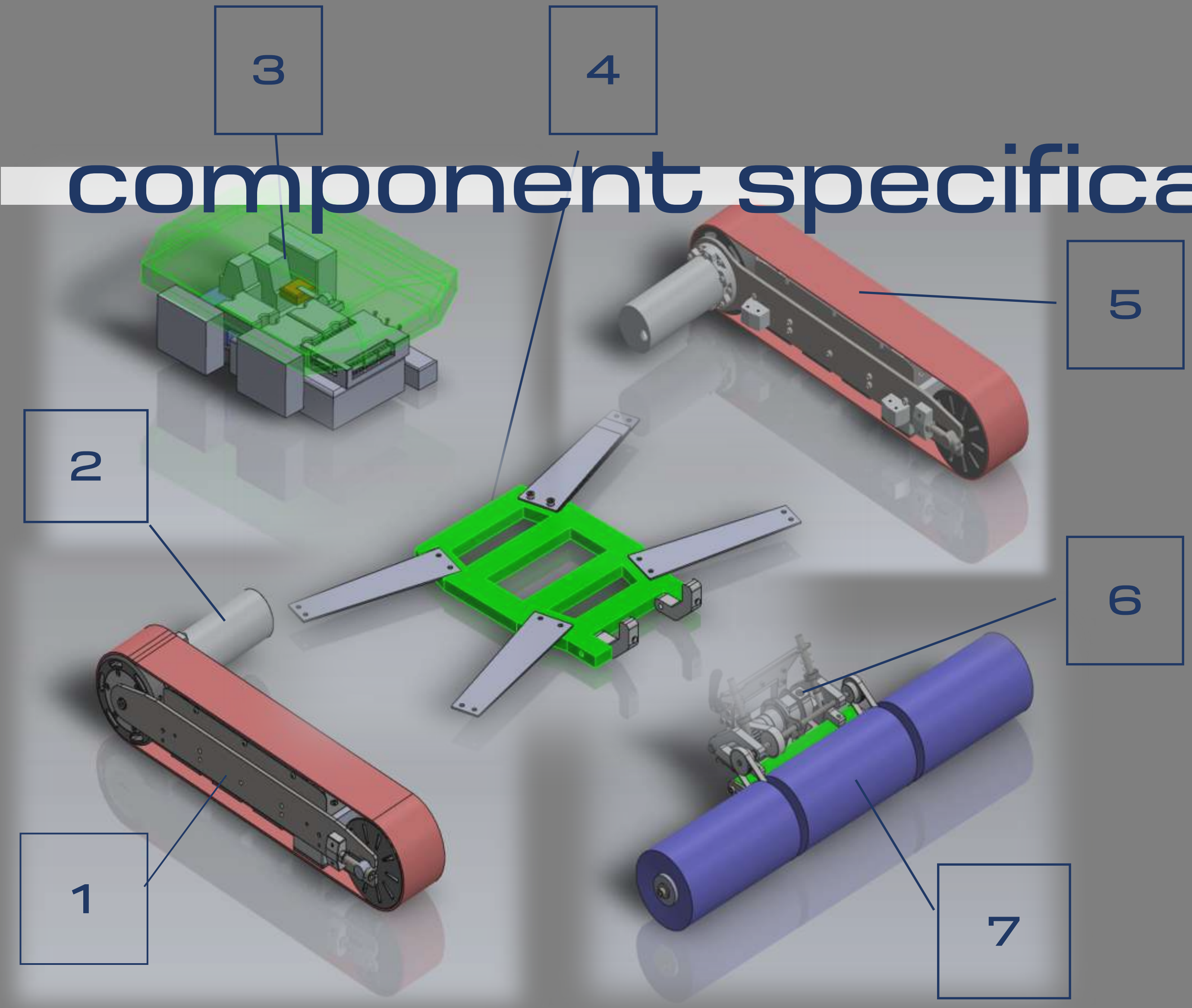

1 | MAGNETIC TRACK

2 | HIGH PERFORMANCE GEARMOTOR

3 | NAVIGATION AND CONTROL SYSTEM

4 | CHASSIS

5 | RUBBER TIMING BELT

6 | GROOMING MODULE

7 | GROOMING HEAD

grooming head specification

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Item	Value | Description
Brush type(s)	Cylindrical Brush, Polyamide | Polyester
Brush Diameter	130 mm
Brush Width	800 mm

arrangement of installation

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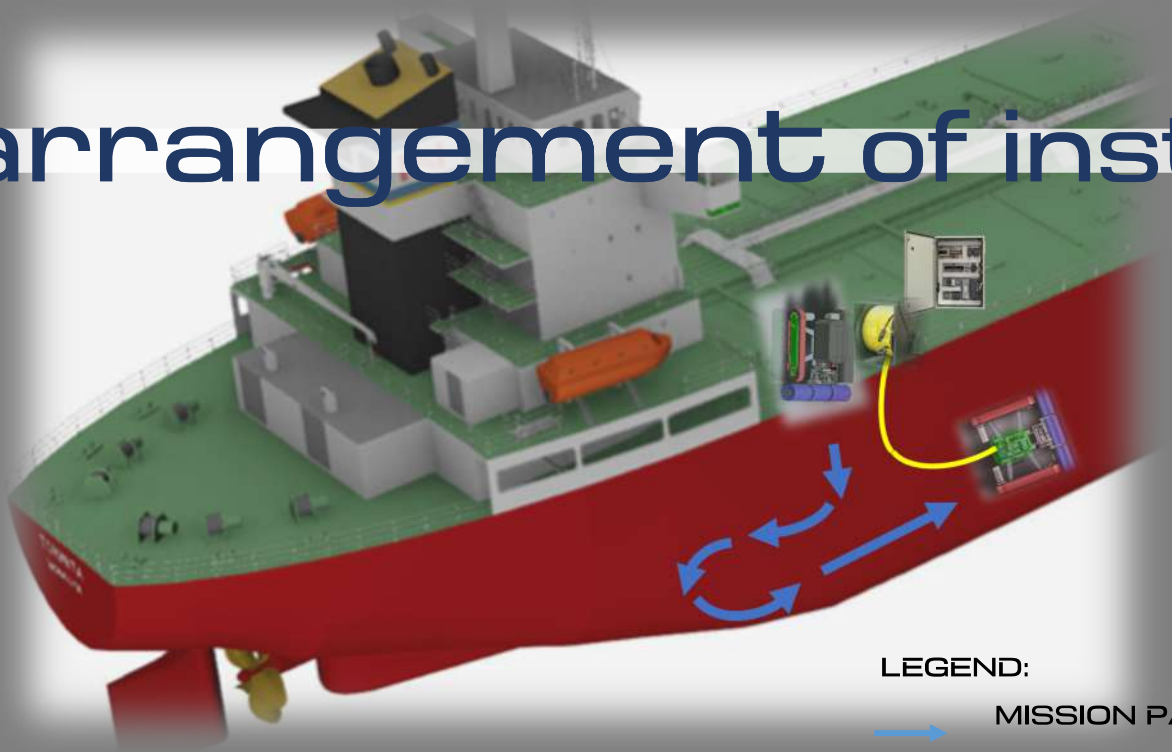
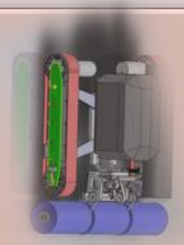


LEGEND:

MISSION PATH

UMBILICAL

Item	Description
	Power Supply Cabinet
	Umbilical System
	Base Station with Crawler

deployment locations

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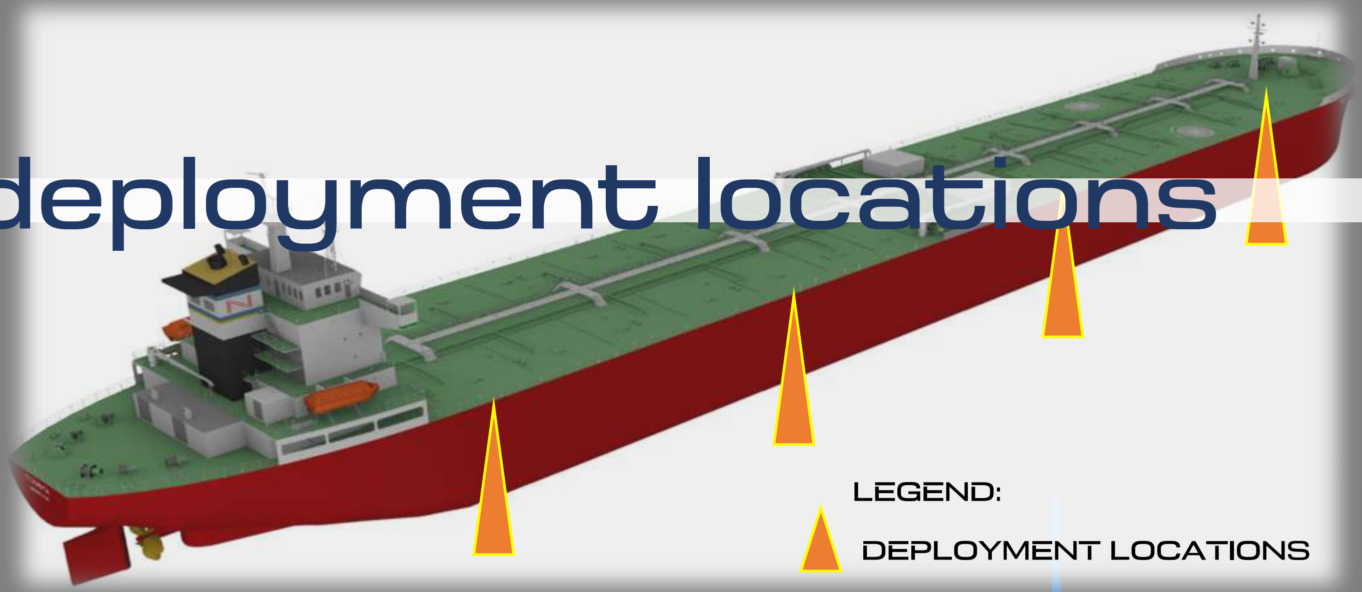

mission path

deployment locations

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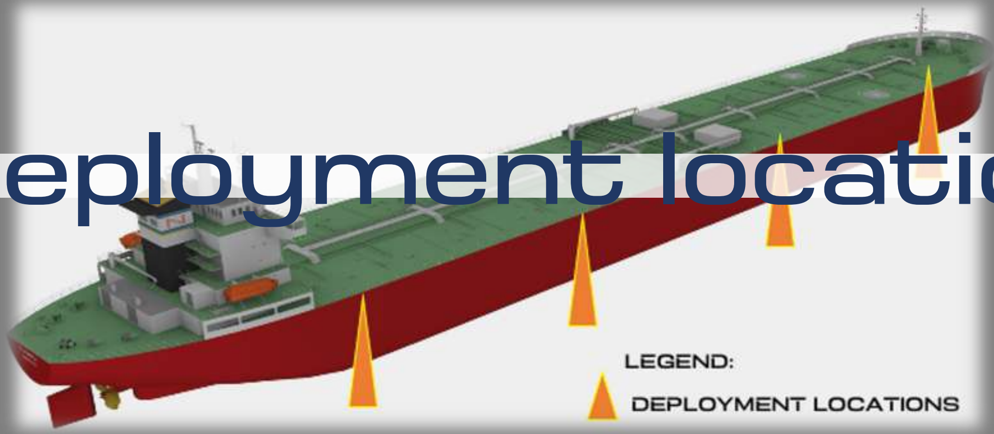

Vessel Type	Feedermax	Handymax	Panamax Container	Panamax	Kamsarmax	Aframax	Suezmax	Capesize	VLCC
Deployment Locations, No:	3.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	5.0
Inspection Operation, hrs:									
VS ea:	2.6	2.5	2.2	2.9	3.3	3.6	4.5	5.0	5.6
VS Tot:	5.3	5.1	4.5	5.9	6.7	7.1	9.1	9.9	11.1
FB:	3.3	3.6	4.6	4.5	4.1	5.9	8.0	7.6	13.2
Total, hrs:	**8.6**	**8.6**	**9.0**	**10.4**	**10.7**	**13.0**	**17.1**	**17.6**	**24.3**
Grooming Operation, hrs:									
VS ea:	3.6	3.4	3.0	4.0	4.6	5.0	6.3	7.0	7.7
VS Tot:	7.1	6.8	5.9	8.1	9.2	9.9	12.6	13.9	15.4
FB:	4.6	5.0	6.5	6.4	5.8	8.4	11.5	11.0	19.2
Total, hrs:	**11.8**	**11.8**	**12.4**	**14.5**	**15.0**	**18.4**	**24.1**	**24.9**	**34.6**

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presentation: 20 May 2021

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Biofouling on Vessels Arriving to New Zealand [1]
CRMS-BIOFOUL | **15 November 2018**

Technical Guidance on Biofouling Management for Vessels Arriving to New Zealand [2]
MPI Technical Paper No: 2018/07

Anti-Fouling and In-Water Cleaning Guidelines [3]
Australian Government | Dept of Agriculture and Environment

Procedures for evaluating in-water systems to remove or treat vessel biofouling [4]
MPI Technical Paper No: 2015/39

current regulation

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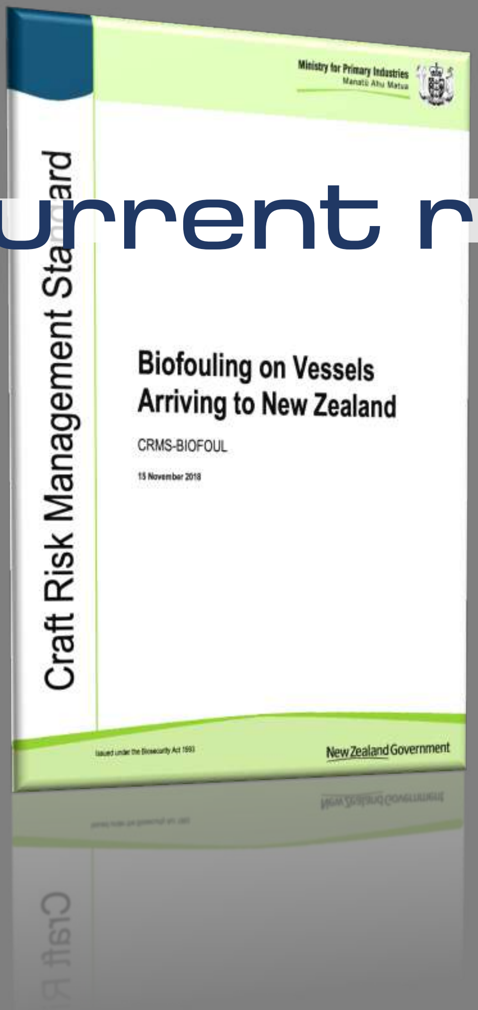

[1] **2.2 Acceptable measures for meeting the standard**

(1) **One** of the following measures must be applied to meet the ‘Clean Hull’ requirement:

a) Cleaning before visit to New Zealand, (or immediately on arrival in a facility or by a system, approved by MPI). All biofouling must be removed from all parts of the hull and this must be carried out less than 30 days before arrival to New Zealand or within 24 hours after time of arrival.

b) Continual Maintenance using best practice, including: application of appropriate antifouling coatings; operation of marine growth prevention systems on sea-chests; and **in-water inspections with biofouling removal as required.**

c) Application of Approved Treatments. Treatments are approved and listed under the Approved Biosecurity Treatments MPI-STD- ABTRT.

[1] CRMS-BIOFOUL | **15 November 2018**

current regulation

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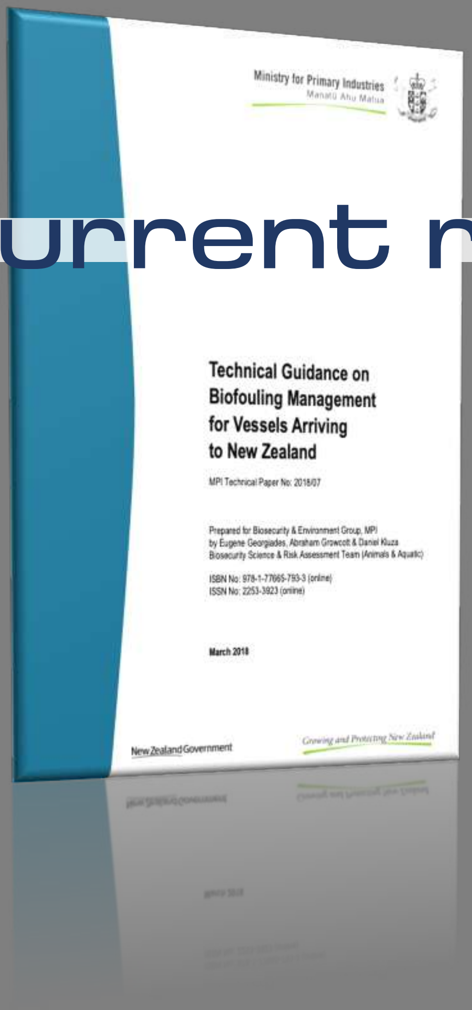

[2] Proactive in-water cleaning and treatment can manage biofouling, at the slime layer stage, to optimise vessel operational efficiency. The economics of removing the slime layer by proactive in-water cleaning are well documented.

Proactive in-water cleaning of a slime layer can be undertaken without the need for full containment of biofouling waste, provided the cleaning method is consistent with the antifouling system manufacturer's recommendations and discharges meet local standards or requirements. A gentle, non-abrasive technique will minimise the release of unacceptable levels of chemical contaminants.

[2] CRMS | **MPI Technical Paper No: 2018/07**

current regulation

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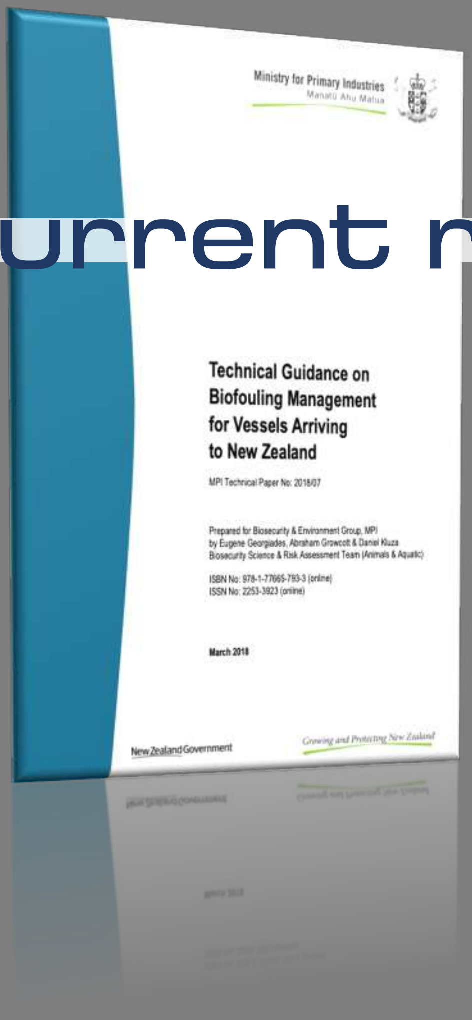

[2] The following points should be considered prior to application of in-water cleaning or treatment:

1. In-water cleaning or treatment methods are acceptable only if the contaminant discharges from the activity comply with the standards or requirements set by the relevant authority.
2. Microfouling, regardless of origin, **may be removed or treated without the need for full containment of biofouling waste**, provided the cleaning method is consistent with the antifouling coating system manufacturer's recommendations. Where microfouling is removed using a gentle, non-abrasive cleaning technique, the chemical contamination risk is likely to be minimised to an acceptable level.
3. Proactive in-water cleaning or treatment is an effective measure to limit biofouling accumulation..

[2] CRMS | **MPI Technical Paper No: 2018/07**

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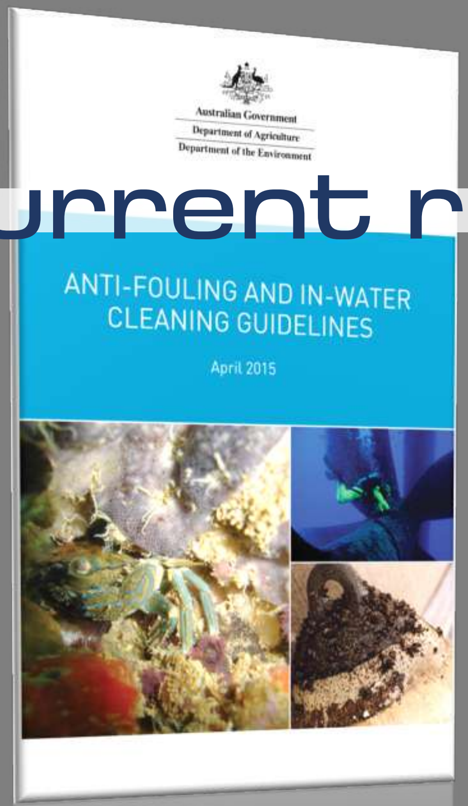

[3] **Recommendations for decision making on in-water cleaning** [3]

- Microfouling, regardless of origin, may be removed without the need for full containment of biofouling waste, provided the cleaning method is consistent with the coating manufacturer’s recommendations. **Where microfouling is removed using a gentle, non-abrasive cleaning technique, the contamination risk is likely to be acceptable.**
- Macrofouling of regional origin (as defined by the relevant authority) **may be removed** without the need for full containment of biofouling waste provided the cleaning method is consistent with the coating manufacturer’s recommendations and the contaminant discharges meet any local standards or requirements. Some relevant authorities will be assessing macrofouling of regional origin and may require consideration of guidance in point 8 (above).

[3] Australian Gov | **AF and IW Cleaning Guidelines**

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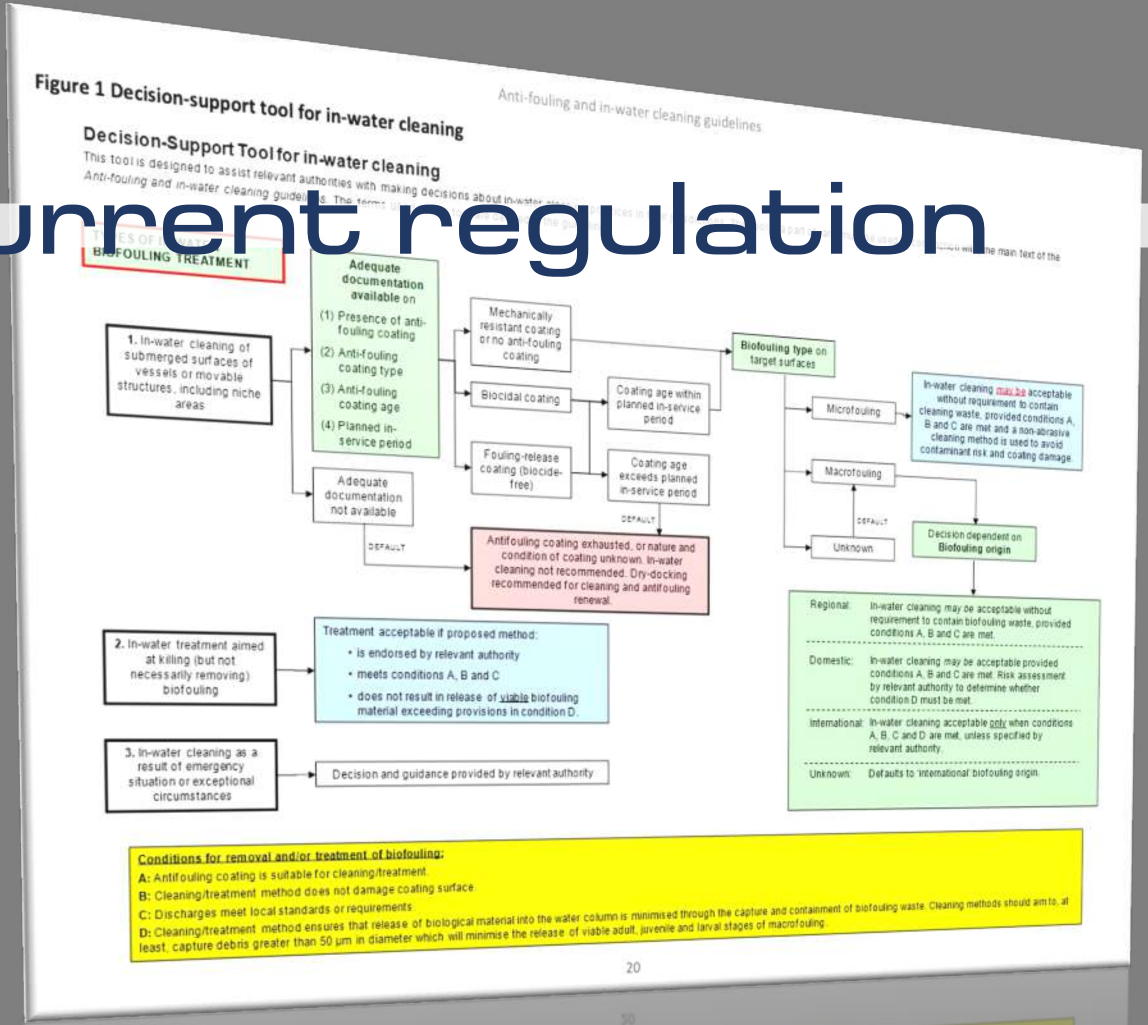

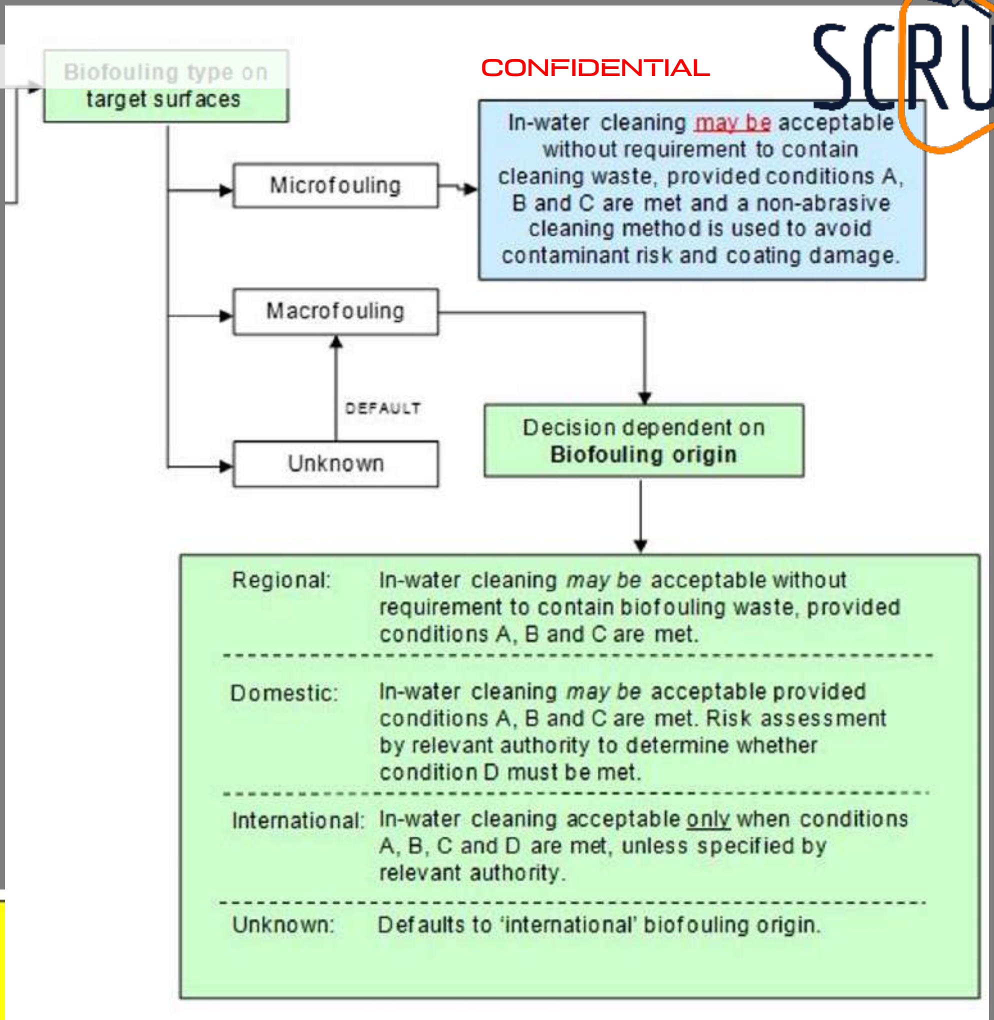

<u>**Conditions for removal and/or treatment of biofouling:**</u>

A: Antifouling coating is suitable for cleaning/treatment.

B: Cleaning/treatment method does not damage coating surface.

C: Discharges meet local standards or requirements.

D: Cleaning/treatment method ensures that release of biological material into the water column is minimised through the capture and containment of least, capture debris greater than 50 µm in diameter which will minimise the release of viable adult, juvenile and larval stages of macrofouling.

[3] Australian Gov | **AF and IW Cleaning Guidelines**

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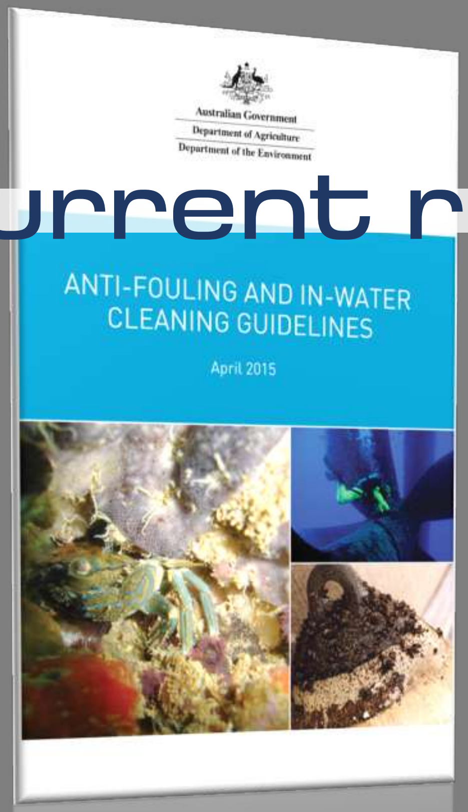

Macrofouling growths represent a greater biosecurity risk as they may contain a diverse range of organisms and are more difficult to effectively remove and contain.

The type of biofouling on a vessel or movable structure can be determined by inspection (either by divers or remotely-operated cameras). **Documentation of an inspection, such as an entry in a Biofouling Record Book, and/or a copy of a report of the inspection, may be adequate evidence of the type of biofouling on a vessel or movable structure.**

[3] Australian Gov | **AF and IW Cleaning Guidelines**

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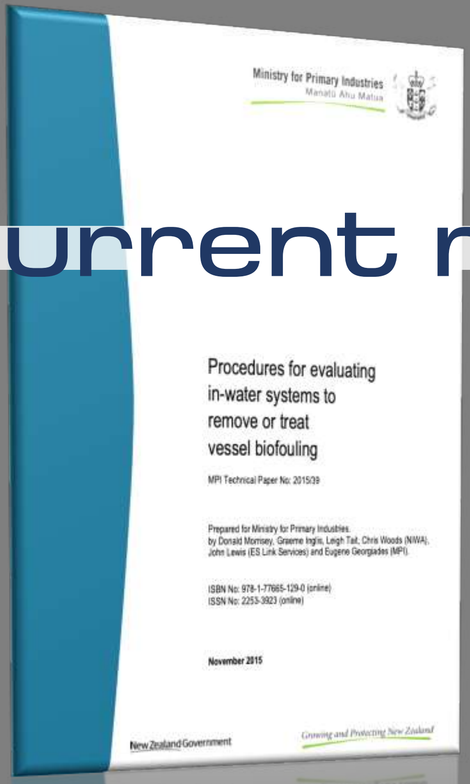
Ministry for Primary Industries
Manatū Ahu Matua

Procedures for evaluating in-water systems to remove or treat vessel biofouling

MPI Technical Paper No: 2015/39

Prepared for Ministry for Primary Industries
by Donald Morrisey, Graeme Inglis, Leigh Tait, Chris Woods (NIWA), John Lewis (ES Link Services) and Eugene Georgiades (MPI)

ISBN No: 978-1-77665-129-0 (online)
ISSN No: 2253-3923 (online)

November 2015

New Zealand Government

Growing and Protecting New Zealand

[4] 3.1.2 Level and cover of biofouling on the test surface

The test surface must be fouled *to the highest level for the intended use of the system* as specified in the system description (Section 3.1.1). For the purposes of testing, four categories of biofouling are defined, based on the US Navy FR scale to define the type of biofouling (Naval Ships' Technical Manual 2006) and Floerl *et al.* (2005) to define percentage cover.

The four categories of biofouling type are:

- slime (FR 20 or less). In-water removal or treatment of slime is considered to be of low biosecurity risk and systems intended for use only on slime **do not require testing under the present framework**;

[4] MPI | **Procedures for evaluating in-water systems**

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REVISION 5

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 081

WATERBORNE UNDERWATER HULL CLEANING OF NAVY SHIPS

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Table 081-1-1 FOULING RATINGS (FR) IN ORDER OF INCREASING SEVERITY

Type	Fouling Rating (FR)	Description
Soft	0	A clean, foul-free surface; red and/or black AF paint or a bare metal surface.
Soft	10	Light shades of red and green (incipient slime). Bare metal and painted surfaces are visible beneath the fouling.
Soft	20	Slime as dark green patches with yellow or brown colored areas (advanced slime). Bare metal and painted surfaces may by obscured by the fouling.
Soft	30	Grass as filaments up to 3 inches (76 mm) in length, projections up to 1/4 inch (6.4 mm) in height; or a flat network of filaments, green, yellow, or brown in color; or soft non calcareous fouling such as sea cucumbers, sea grapes, or sea squirts projecting up to 1/4 inch (6.4 mm) in height. The fouling can not be easily wiped off by hand.
Hard	40	Calcareous fouling in the form of tubeworms less than ¼ inch in diameter or height.
Hard	50	Calcareous fouling in the form of barnacles less than ¼ inch in diameter or height.
Hard	60	Combination of tubeworms and barnacles, less than ¼ inch (6.4 mm) in diameter or height.
Hard	70	Combination of tubeworms and barnacles, greater than ¼ inch in diameter or height.
Hard	80	Tubeworms closely packed together and growing upright away from surface. Barnacles growing one on top of another, ¼ inch or less in height. Calcareous shells appear clean or white in color.
Hard	90	Dense growth of tubeworms with barnacles, ¼ inch or greater in height; Calcareous shells brown in color (oysters and mussels); or with slime or grass overlay.
Composite	100	All forms of fouling present, Soft and Hard, particularly soft sedentary animals without calcareous covering (tunicates) growing over various forms of hard growth.

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Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (22 Photos)

Figure 081-1-1 (SH1) FR-10, Over 30 Percent Of Area (Sheet 1 of 22).

Figure 081-1-1 (SH2) FR-10, Over 100 Percent Of Area (Sheet 2 of 22).

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Figure 081-1-1 (SH3) FR-20, Over 80 Percent Of Area (Sheet 3 of 22).

Figure 081-1-1 (SH4) FR-30, Over 40 Percent Of Area (Sheet 4 of 22).

Q & A

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thank you.
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